FINAL REPORT

Geothermal Public Health Assessment

FINDINGS & RECOMMENDATIONS

Submitted By

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PROJECT DIRECTOR

On Behalf of

The Geothermal Public Health Assessment Study Group

SEPTEMBER 9, 2013

The Original Geothermal Public Health Assessment Study Group [1]

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- Daniel DiDomizio *
- Edward Fisher *
- James Haefner
- LaRee Ann Hiltner
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- René Siracusa
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[1] Due to other commitments, Dan DiDomizio, Maile Tualiʻi, and Edward Fisher were unable to complete their participation in the Study Group's 9-month process.

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Second, to all members of the public who came to meetings, patiently observed, listened hard, and offered constructive comments on the substance and process of the Study Group's work.

Third, to Newton Inouye of the Department of Health, Michael Kaleikini of Puna Geothermal Venture, Jeffrey Melrose, our County of Hawai'i point of contact, Jon-Pierre Michaud of University of Hawai'i-Hilo, and F. DeWolfe Miller of the John Burns School of Medicine who served as liaisons and brought forward documents and views for the Study Group's consideration. All of these individuals provided us with valuable meteorological, historical, public health, and geological information.

Last, to the Project Team who did an extraordinary amount of heavy "lifting" to support the Study Group and bring this project to fruition: Ms. Keala Carter of ACCORD3.0, Ms. Catherine Lampton of Mediation & More, and Mr. Xavier Matsutaro of the Department of Urban and Regional Planning, University of Hawai'i at Mānoa.

Peter S. Adler, PhD
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Partial List of Terms & Abbreviations

ATSDR	U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry
Anxiety Disorder	An umbrella term for a variety of problems including excessive worry, fears, uneasiness, apprehension, ruminations, panic, and post-traumatic stress.
BACT	Best Available Control Technology
BLNR	Board of Land and Natural Resources
Caustic Soda	Sodium hydroxide or lye, which is used in the emergency bypass system to help mitigate the effects of H2S
CDUP	Conservation District Use Permit
CNS	Central Nervous System
COPD	Chronic Obstructive Pulmonary Disease
dBA	The power of noise calculated in decibels
DOH	Department of Health
DLNR	Department of Land and Natural Resources
EPA	U.S. Environmental Protection Agency
GW	Gigawatts, equal to one billion watts
HCCD	Hawai‘i County Civil Defense
HELCO	Hawai‘i Electric Light Company
H2S	Hydrogen Sulfide

HGP-A	Hawai‘i Geothermal Project’s (HGP) initial test plant
JFF	Joint Fact Finding
MW	Megawatts, equal to one million watts
MA	Meta-analysis—a systematic review of a set of studies and their methods
Peer Review	Evaluation of an expert’s work by one or more other experts who have similar competencies, usually for purposes of acceptance for publication
Pentane	A hydrocarbon used as a working fluid in geothermal energy operations
ppb & ppm	Parts per billion and parts per million. The number of parts per million is equal to the number of parts-per billion divided by 1000. 1 ppm = 1,000 ppb.
PGV	Puna Geothermal Venture L.P., a subsidiary of Ormat Technologies, Inc.
Rankine Scale	Rankine degree is a measurement scale used by some engineering fields. A temperature of −459.67 °F is exactly equal to 0 °R.
RFP	Request for Proposal
Rift Zone	Specifically, the Kīlauea East Rift Zone, a volcanic source of heat underneath part of Hawai‘i Island
UH	University of Hawai‘i
Upset Condition	Anything other than normal operations at a geothermal plant; sometimes referred to as an “incident”
USGS	U.S. Geological Survey
Vog	Volcanic smog

Executive Summary

In September, 2012 Hawai‘i Island Mayor William Kenoi asked Peter S. Adler, PhD of ACCORD3.0 if he would organize an independent “joint fact finding” Study Group that would examine the type and extent of health impacts from Hawai‘i Island geothermal operations. Hawai‘i County Council members had shown interest in such an effort, and the Mayor expressed his own belief that public officials, regulators, and residents must consider the health risks that may be associated with geothermal energy production.

The specific aims of the project were to:

1. List the public health questions pertinent to the production of geothermal energy in the Puna region;

2. Create a reliable inventory of existing studies that addresses those public health concerns and that could serve as references for decision-makers; and

3. Recommend the priorities and preferred methodologies for future scientific and monitoring studies that may be required or that can best assist the County and the Windward Planning Commission to make informed decisions that protect the long term health of the community.

Findings

1 Puna’s public health profile is unclear

Puna’s overall public health appears worse than the County and State as a whole. We do not have an accurate and readily available profile of disease and illness patterns for the past and current populations of Puna, and more particularly, for Lower Puna. A health profile could provide a better basis for understanding geothermal health issues. Usable and pertinent public health information should normally include statistics on mortality (heart disease, malignant neoplasms, cerebrovascular disease, respiratory illness, unintentional accidents, etc.); actual causes of death (accidents, tobacco, alcohol, microbial agents, toxic agents, etc.); actual disabilities (arthritis, diabetes, chronic back problems, impaired vision, etc.); and detailed mortality and morbidity information by age, ethnicity, and length of

time in Puna. An accurate health picture would normally also include clinic and hospital admissions, numbers of days of sickness, and other statistical snapshots.

2 Health studies are needed

Events during the HGP-A era and during the 1991 blowout provided exposures associated with adverse health effects. This knowledge, along with other information contained in this report and referenced in Annexes-3 and -4 has led the Study Group to conclude there is evidence that there were health effects from the exposures during the development of geothermal before 1993. The full extent and severity of those effects has not been documented.

After 1993, the Study Group is less certain about whether there have been health effects and what the extent and severity of the effects might be. In 1996, Dr. Marvin Legator conducted a study of Puna residents that showed significantly higher adverse health effects normally associated with industrial H2S than three reference communities.

3 Geothermal operations carry health risks

Risks from geothermal energy production in Lower Puna exist. The actual extent and impacts of those risks remains unresolved. What is known is that hazardous chemicals are brought up by PGV. PGV adds industrial chemicals to the mix in the process and then sends the composite fluid back down. However, fluids inevitably escape to air, water, or at surface level. Harmful effects can only be understood through better monitoring and reliable health data.

Recommendations

1 Undertake a comprehensive health effects study

Using robust scientific methodologies, the County should commission a comparison group study to test four hypotheses:

A CNS degradation of the sample population will likely be more pronounced as a function of highest peak exposure to H2S. Other symptoms, particularly respiratory effects, may be more pronounced as a function of length and extent of exposure, as well as time since exposure.

B CNS and other negative health effects from exposure to emissions including

H2S will be greater in areas of highest exposures. Such exposures will be a function of meteorological conditions and emission rates over plant history.

C Heavy metal and other chemical contamination from geothermal energy production sources may have spread into the soil and into water catchments and affected drinking water supplies. This spread of heavy metals could cause health effects to residents in proximity to geothermal plants.

D As a consequence of noise and vibration, residents who have (a) lived closest to geothermal project development; (b) directly experienced geothermal gas releases; (c) have been evacuated; (d) or have experienced the highest noise and vibration levels may be more likely to show anxiety disorder symptoms.

2 Conduct a review & meta-analysis of H2S health effects

The Study Group believes the literature of H2S health effects related to low-level, long-term geothermal development has not been adequately reviewed. In addition to traditional literature reviews, one of the best methods to accomplish a robust review is a "meta-analysis" of all relevant information on the H2S topics covered by this report. We recommend that a literature review and MA be performed on the Study Group's topic of primary health concern: the effects of geothermal-derived H2S on CNS and respiratory function.

3 Establish a better monitoring system

Current monitoring systems and protocols are inadequate and must be substantially improved. Because responsibility for the monitoring and reporting of exposures is decentralized across different agencies, an effective communication protocol, especially in the event of an emergency, is also essential. The County of Hawai'i is the layer of government closest to the day-to-day lives of its citizens, and the health and welfare of its citizens must take precedence over geothermal interests. County of Hawai'i needs to ensure that reliable gas, particle, meteorological, and noise data are readily available to its citizens in near real time, so that residents can make informed decisions to protect themselves from fugitive emissions.

4 Evaluate geothermal effects on drinking water & near-ocean environment

Geothermal energy production involves drilling through various geological layers, creating a possible risk of water contamination downstream of the reinjection site. As a separate initiative, the County should commission USGS to study the

consequence of brine re-injection. Ocean contamination and possible near-shore die off should also be studied. Using robust scientific methodologies, the County should test the following hypotheses:

A Brine that is deeply re-injected into the lower East Rift geothermal zone could be migrating vertically into near-surface water flows, causing contamination of the aquifers and the ocean shore brackish basal ground waters.

B Contamination of the ocean shore waters caused by geothermal development could be affecting coastal and near-shore plant and animal life. (Pentane, along with other chemicals which should not be present or certain injectate components, could serve as markers for injection fluid migration.)

5 Assure the credibility, reliability, & independence of health study experts

The Study Group recommends a three-group process. The first group is an independent group of professionals that administer the RFP, evaluate proposals, and submit a ranking of the proposals with comments justifying that rank. The second group would be a cross-section of the community proximate to where a geothermal plant is proposed. The final group would be the County personnel that handles the legal and financial issues involved in setting up a contract.

6 Ensure there is no old or ongoing contamination from HGP-A

The Study Group recommends that the County use the full strength of its influence with State and federal agencies and private landowners to ensure the old HGP-A site is free of contaminants. Soils and water channels in the area of the five old HGP-A brine pits should be studied with vertical samples deep enough to go beyond the fill used to cover old pits. Any survey should examine whether and to what extent contamination occurred and what re-mediations, if any, may be required.

7 Strengthen public communications & alerts

Since geothermal energy production involves health and safety risks, announcements, messages, and emergency declarations must reach the public in a timely manner, especially those in close proximity to geothermal operations. The more severe the condition, the more urgent the communication required. We urge the County to install and update its notification procedures and consider a variety of mechanisms to provide alerts to the public when upset conditions occur.

8 Any future geothermal developers should fund, & the County should commission, water resource & health baseline studies to be done prior to future geothermal drilling & development

Geothermal development can affect the health and wellbeing of people surrounding the plant during dramatic accidents like the KS-8 blowout in1991 and potentially during smaller upsets and operational releases such as occurred in 1997 and 2005. By establishing a baseline health study that measures the same parameters explored in Recommendation 1, future health studies can more easily establish the magnitude and responsibility of health effects.

Further, geothermal development may affect water wells downstream from the development area as well as the coastal basal brackish groundwater and the ocean near the geothermal plant. By establishing a baseline using the methodology of the study of Recommendation 4, future water studies will be able to more easily establish the magnitude and possible responsibility for environmental impact from geothermal development. If possible, USGS should conduct this study.

I

Introduction & Background

Geothermal energy is power derived from heat contained in the rock and fluids beneath the Earth's crust. To produce geothermal electricity, wells are drilled into underground reservoirs to tap steam and hot water that is then brought above ground to drive turbines linked to electrical generators. The United States is the world's largest producer of geothermal energy though many plants are in place in Iceland, Italy, Japan, and 20 other countries. Worldwide and according to the Geothermal Energy Association, about 11,224 MW of geothermal power are online. An additional 51 GW of geothermal are installed for direct heating, space heating, spas, industrial processes, desalination, and agricultural applications.

Geothermal energy can be extracted without burning fossil fuels such as coal, gas, or oil. When operating optimally, many geothermal plants produce about one-sixth of the carbon dioxide of a natural-gas-fueled power plant. Geothermal energy can reduce the need for imported fossil fuels and reduces greenhouse gas emissions. Closed-loop plants such as PGV in the Puna District of Hawai‘i Island, are designed to produce only minor gaseous emissions during normal plant maintenance. Unlike solar and wind energy, whose production rates vary over time and weather conditions, the energy source of geothermal plants is typically constant throughout the day and over decades. Geothermal production plants can be operated so that the cost of the produced electricity is comparable to that of plants using fossil fuels.

But geothermal power production can have negative impacts on human health and ecosystems. Geothermal production plants do not always operate optimally as designed and can emit substances at concentrations that may harm human health if not properly controlled. One example among several chemical constituents is H2S, a gas that smells like rotten eggs, is known to be toxic to humans at high concentrations, and may have long-term negative impacts at lower concentrations. The human nose is extremely sensitive to H2S and can detect it as low as 3 ppb.

The ecosystems in which geothermal plants are located can also be damaged by the accidental release of both wind-borne and ground-water contaminants.

By nature, closed-loop geothermal production plants that require deep drilling are often located in seismically unstable geological formations. Drilling and reinjection processes increase seismic activity patterns. Finally, geothermal facilities are industrial sites that can permanently change the character of a neighborhood or community. These may have positive impacts in terms of jobs, commerce, and better infrastructure but they also can create undesirable noise, pollution, traffic, social and cultural impacts, and other site-specific effects.

Project Initiation

The State of Hawai‘i has been encouraging the development of geothermal energy production since the 1970s. Two plants have been developed, the first a now inactive experimental pilot operation called HGP-A. The second, PGV, is a fully commercialized operation owned by Ormat Technologies Inc. and is currently contracted to produce 38 MW of electricity. Expanded operations are planned. Six bids are currently under consideration by HELCO for further geothermal energy production including PGV. Some of the remaining five bidders plan to locate their operations in the East Rift Zone, one of which is adjacent to the PGV property.

Throughout the years of exploration and development and continuing to the present, residents in Lower Puna have registered concerns and complaints about both HGP-A and PGV, some brought to previous County Councils, Mayors, and Civil Defense Directors, some to state and federal agencies, some in lawsuits. This report emanates from those concerns.

In September 2012, Hawai‘i Island Mayor William Kenoi asked Peter S. Adler, PhD if he would organize an independent project that would examine the type and extent of health impacts from Hawai‘i Island geothermal operations. Hawai‘i County Council members had shown interest in such an effort, and the Mayor expressed his own belief that public officials, regulators, and residents must consider the health risks that may be associated with geothermal energy production.

After discussion and assurances that the inquiry would focus on the best factual information available and be conducted without political interference or advocacy, Adler was contracted to undertake a “joint fact finding” approach that would involve scientists, knowledgeable community leaders, medical clinicians, and others with experience and interest in the subject.

Adler's plan, approved by the Mayor's office, was to assemble a small project team, prepare a project overview (Annex-5, "Project Description"), conduct a round of confidential interviews to understand the history and current views of geothermal health issues, and then bring together a sustained and science-focused "Study Group" engaged in joint and mutual fact finding. Information on the project and the deliberations would be made available at a website and meetings would be held in the Puna District. Interested members of the public would be able to offer their ideas and views at the end of each meeting. Adler's contract was for $50,000 inclusive of all expenses related to the project.

Goals & Deliverables

The specific aims of the project were to:

1. List the public health questions pertinent to the production of geothermal energy in the Lower Puna region;

2. Create a reliable inventory of existing studies that addresses those public health concerns and that could serve as references for decision-makers; and

3. Recommend the priorities and preferred methodologies for future scientific and monitoring studies that may be required or can best assist the County and the Windward Planning Commission to make informed decisions that protect the long-term health of the community.

Caveats to this Report

1 Joint Fact Finding

JFF is a strategy that brings experts and knowledgeable public stakeholders, often from opposing angles on an issue, to work together to resolve or narrow factual disputes over important environment, energy, public health, and social policy issues. It should not be construed as scientific research. In this case, the JFF effort was done through a "Study Group" approach with persons who agreed to participate on a volunteer basis. The procedure is flexible but generally seeks to help frame high priority research questions and identify, generate, analyze, or interpret the scientific and technical information that can be used to inform a decision or action.

2 Scope of the Report

This report is not exhaustive of all issues, facts, and controversies surrounding geothermal health matters. In fact, the great preponderance of the group's deliberations focused on the health effects of H2S.

In keeping with the Study Group's mandate, this report includes:

- A list of issues of highest immediate concern to the Study Group;
- A list of many but not all of the different peer-reviewed and non-peer-reviewed materials examined can be found at Annexes -3 and -4; and
- Major findings and recommendations for better monitoring and focused health studies.

Because a specific issue, problem, or concern is not listed, readers should not assume there is no problem.

3 Uncertainty & Precaution

The Study Group has sought to balance three important inquiry principles. First, an understanding about what public health issues Study Group members are most concerned. Second, insights into what the settled and still-evolving science can tell us about geothermal related health issues. Third, a reasonable precautionary approach erring on the side of long-term public health and safety considerations when conventional risk analyses cannot settle issues with certainty. This required consideration of non-peer-reviewed literature and science that is still evolving and not considered fully settled.

4 Focus on "Hypothesis" & "Method"

In keeping with the mandate from Mayor Kenoi, the Group has sought to articulate the hypotheses and general methodologies of recommended health studies allowing the County to pursue. These include how the qualifications of prospective experts should be solicited, vetted, and opened to all qualified researchers.

5 Resource Materials and Citations

Members of the Study Group reviewed a large number of studies, research reports, data sets, legal records, plant operating data, government records, and other empirical information. A listing of these materials is at Annexes-3 and -4, and the content of Annex-4 is electronically available to the County of Hawai‘i and,

through the County, to the public. Peer-reviewed studies have been noted with a check mark (√).

From an academic point of view, it would normally be important that any study or research report cited in a bibliography have a clear attribution of its cited sources. Independent reviewers would then be able to follow the intellectual trail back to the beginning to see if the cited studies are built on strong methodological and analytic foundations. This would give researchers opportunities to make their own assessments of the foundational reliability of information they have developed.

Given the volume of materials examined and the limitations of the Study Group, the materials listed at the end of chapters or in the Annexes have not been vetted this way. They are included in this report as a compilation of references and are not meant to be an exhaustive presentation or distillation of all relevant literature.

6 Geothermal Policy

While Study Group members hold different political views regarding geothermal energy development, the Group takes no collective position on those debates other than an overriding unanimous belief in the need for useful and more definitive health studies. The Group understands that assessments like this will inevitably be used in larger policy conversations, yet has limited its focus to public health and safety. In the words of one Study Group member: "We are not anti-geothermal, but any geothermal enterprise must be safe for the community, for plant operators, for the county, and for investors."

7 Agreement & Disagreement

The original design of the project anticipated three types of Study Group members: (1) knowledgeable persons from the community; (2) medical clinicians; and (3) scientists with pertinent specialties. As described later, several members of the initial group were unable to fully participate which left the group less than fully balanced. Despite this, Study Group members find many areas of agreement. There are also points of divergence.

At Annex-1, Study Group members have added additional perspectives, dissents and reservations, or recommendations that go beyond the scope of this report. Some members disagree with certain specific parts of the eight recommendations. Therefore, unless specifically noted in the individual statements of Study Group members at Annex-1, the report comes to Mayor Kenoi and other readers with "no basic objections beyond the dissents indicated in the personal statements."

Initial Interviews

From late September to November of 2012, Peter Adler conducted nearly 30 confidential interviews with community members, scientists, physicians, public health experts, and others to identify potential Study Group members and to better understand the different views of geothermal health issues. The preponderance of interviews was conducted with persons living in Puna, many of whom were intimately familiar with the history and operations of geothermal energy extraction. Others interviewed included epidemiologists, toxicologists, medical clinicians, public health experts, and researchers both on Hawai‘i Island, O‘ahu, and elsewhere.

Every profession, every community, every family, every culture group, every organization, every government agency, and every dispute has one or more "narratives" that are told by stakeholders to summarize many particulars. The Adler interviews initially revealed seven broad narratives about geothermal health matters:

1 The "Hazardous" Narrative

PGV, and HGP-A operations before it, are dangerous. There are unsafe constituent elements – metals, gases, particulates, and solids – that are coming up in the brine and steam. These are then sent down through reinjection, lost to air or water, or disposed of on- or off-site. These present serious threats to human and environmental health.

2 The "Safe" Narrative

PGV is benign. The operational problems of the past, including the 1991 blowout, have been remedied, the plant's operations are well monitored and regulated, and from a public health standpoint, the current operational version of geothermal energy production is harmless.

3 The "Frustration" Narrative

PGV and the predecessor HGP-A operation have created real annoyance and irritation, most especially for those who live close to the plant and had no say in its location. There is periodic noise, smell, and vibration. For most people who experience these, the conditions are irritating. However, these problems are annoyances and don't rise to the level of being dangerous. As one person put it, "PGV isn't a disaster, but not everything is OK."

4 The "Poor Planning & Oversight" Narrative

Like any industrial operation, geothermal development carries risks. Workers must be protected by regulation, as must local populations outside the

project's fence line. Puna is the wrong location for an industrial plant. It was and remains an inhabited rural area. Geothermal energy production exacts a toll on the community without (corresponding benefits.) In the case of Puna's facilities, proper planning and oversight by regulators and politicians has been woefully inadequate.

5 The "Undecided" Narrative

Currently, it isn't clear whether geothermal operations in Puna are safe, unsafe, or somewhere in between. Future geothermal energy development is at the center of larger political concerns about energy and land use and in which science gets used as a sword or shield, depending on one's views. Science always has debate and uncertainty, but we are obligated to use the best-substantiated knowledge available to inform decisions, even if those decisions may be imperfect. At the moment, matters are unclear.

From public comments received on August 15, 2013, two additional stories emerged.

6 The "Native Hawaiian Health" Narrative

Native Hawaiians, especially Pele practitioners, have suffered additional health harms because geothermal energy development is a cultural and religious desecration. Geothermal energy development on top of other historical dispossessions now creates unique suffering amongst Hawaiians in ways that stand apart from non-Hawaiians and the conventions of Western science and medicine.

7 The "Stress" Narrative

While the full panoply of health harms may not yet be fully substantiated and documented, geothermal energy development has created a considerable amount of fear, anxiety, and anger. These trepidations are community stressors whether or not long term and widespread health harms are shown to exist.

During the initial interviews, some community members expressed fears in response to specific interview questions.

Question: *What geothermal health-related complaints are uppermost in your mind, or the minds of others you know?*

Responses: Respiratory and pulmonary problems; skin rashes; lesions; cognitive and behavioral disorders; reproductive problems; stress. Embedded in these

responses was a persistent question as to whether there is empirical evidence of illness or disease "clusters."

Question: *From a health perspective, what constituent elements of geothermal operations worry you most?*

Responses: H2S; pentane; SO2; radon; caustic soda (used to neutralize H2S); metals (lead, arsenic, cadmium, chromium, selenium, etc.); excessive periodic noise; continuous low-level noise; vibration; "life and limb" risks (explosions, seismic disturbances, vulnerability to sabotage); radioactivity.

Embedded in these interview discussions were other questions. What is ambient in the East Rift Zone in terms of gases and metals, and what is added by PGV? What, if any, are the impacts to air quality, soil quality, water quality, and offshore waters? What happens when these risks combine or interact? Is there a chemical "soup" in the air, in the water, or on the ground? What does monitoring tell us? Is the monitoring sufficient and reliable, and who is interpreting the results?

Question: *What would reassure you that PGV is safe or confirm that it is dangerous?*

Responses: A definitive public health study that also included all sub-populations; reliable monitoring; better oversight; an outside expert who examined everything; and for some, 'nothing.'

In his first briefing paper to the Study Group, Adler reported his initial impressions:

- First, there are real health fears by those who live closest to the plant and have experienced noise and smell first-hand, especially those who moved to the area before the plant was sited or who experienced the 1991 blowout.

- Second, as often happens on complex issues, many people have their own pieces and parts of the picture but no one has the entire picture. No one has reviewed all of the complaints, all of the pertinent science, and all of the existing public health data.

- Third, many of the concerns were based on individual experiences or anecdotes and, just as often, worries heard from others: "I can smell H2S when I…"; "I have a friend who…"; "Someone told me that…"; "I read that…"; "I'm worried about… "

- Fourth, many people who had read some parts of the expansive scientific and technical literature had developed their own hypotheses about what in particular

may be problematic and had selected scientific studies that support their own theories. In social psychology, this is called "confirmation bias" and everyone is vulnerable to it.

- Finally, everyone wanted to know definitively if geothermal operations are safe or unsafe and, if unsafe, in what ways and to whom.

Selection of Study Group Members

Following the interviews, a number of individuals were asked to become formal members of the Study Group. These individuals agreed that the mission was important, that they would volunteer their time, that diverse views and knowledge sets were important, and that they could abide by the ground rules and expectations for an independent and dispassionate examination of geothermal health issues. The following individuals agreed to serve.

Name	Residence	Experience
Jay Bondesen	Puna	Retired builder. Background experience with materials safety data and hazard. Member and President of the Leilani Estates Board of Directors
Alfred Dettweiler	Puna	Past President of the Leilani Community Association and a long-time resident of Puna. Has extensive background in the history of geothermal energy development in Hawai‘i and has gathered H2S readings in the community
Dan DiDomizio, MPH, PA	Puna	Clinical Programs Director of the Puna Community Medical Center. Resident of Puna District who brings wide-ranging and in-depth experience with public health matters in Puna
Edward Fisher, PhD	Puna	Professor of Pharmacology and Toxicology and Associate Dean for Academic Affairs, UH Hilo School of Pharmacy. Has wide-ranging experience in scientific matters and brings special experience in toxicology
James Haefner, PhD	Puna	Professor Emeritus, Department of Biology and Ecology, Utah State University. Has extensive background in the design, validation, and statistical analysis of system models
LaRee Ann Hiltner, MS	Puna	Degrees in Civil and Environmental Engineering. Brings experience in industrial hygiene, instrumentation, and calibration

Robert Petricci	Puna	Businessman and founder and long-time leader of Puna Pono Alliance. Knowledgeable about geothermal matters generally and, more specifically, the history of geothermal issues in the Puna District.
René Siracusa, MA, ABD	Puna	One of the founders of the Big Island Rainforest Action Group and President of Malama O Puna. Brings long experience in environmental matters and serves as board president of Puna Community Medical Center
A. Jeff Sutton	Puna	Geochemist with the USGS Hawaiian Volcano Observatory. Brings strong background in the chemistry of volcanic gases, the role of gases in eruptive processes, and the effects of volcanic emissions as a volcanic hazard
Laura Travis, RN	Puna	Healthcare experience with expertise in medical issues faced by mothers, infants, retirees, and war injured. Training and service in public health
Thomas Travis, Captain USN (ret)	Puna	Retired submarine captain and deputy battle group commander. Engineering degrees. Brings extensive military and civilian experience in the practical application of analysis and evidentiary standards to complex problems
Maile Tualiʻi, PhD	Honolulu	Brings strong background in public health genetics, informatics, and related behavioral and social sciences coupled with Native Hawaiian cultural perspectives

Over the course of the Study Group's work, Dr. Tualiʻi, Mr. DiDomizio, and Dr. Fisher were unable to complete their participation with the Study Group due to other obligations and the length of the Study Group's process. In addition to the above members of the Study Group, the following individuals agreed to serve as liaisons for the express purpose of providing additional information and/or responding to technical questions.

- Newton Inouye, District Environmental Health Program Chief for the Hawaiʻi District Health Office. Responsible for planning and directing the work of the Vector Control and Sanitation Units of the Hawaiʻi District Health Office.
- Michael L. Kaleikini, Senior Director for Hawaiian Affairs for PGV. Responsible for project development, community affairs, and policy issues in Hawaiʻi.
- Jeffery Melrose, Special Assistant to Mayor Kenoi, County of Hawaiʻi. "Point of contact" and project liaison to County of Hawaiʻi.

- Jon-Pierre Michaud, PhD, MS, Associate Professor of Chemistry at UH Hilo and former faculty member in the Manoa School of Public Health. His PhD is in Toxicology with a focus on environmental toxicant interactions. He also holds an MS in Industrial Hygiene.

- F. DeWolfe Miller, MS, MPH, PhD, professor of epidemiology, microbiology, public health, and tropical medicine at the John A. Burns School of Medicine, University of Hawai‘i. In addition to being a Fellow in the American College of Epidemiology, he has been a Fulbright scholar and has published epidemiological research on both chronic and infectious diseases.

Charter of Commitments

In advance of the first meeting, all Study Group members were asked to submit brief bios or CVs and to fill out a simple "Conflict of Interest" declaration form (posted to the website). They were also asked to come to the first meeting prepared to amend as necessary and then sign a "Charter of Commitments" (Annex-5 – "Charter of Commitments"), which they did. In addition to reiterating the Study Groups' purpose, mission, membership, and means of decision-making, this document served as a working "constitution" for the project and spelled out twelve specific "rules of engagement." With minor word changes, the document was approved and signed at the first meeting.

Study Group Meetings

The Study Group met for face-to-face deliberations on the following occasions:

- January 12, 2013
- February 10, 2013
- March 3, 2013
- March 10, 2013
- April 7, 2013
- May 12, 2013
- August 15, 2013
- August 20, 2013
- September 1, 2013

Most meetings were held on Sunday afternoons, and observers were afforded opportunities to speak at the end of each meeting. In between these meetings, Study Group members engaged in telephone and email discussions, extensive research and analysis, and electronic correspondence, much of it circulating discovered and pertinent documents. An open public meeting to receive drafts comments was held on August 15, 2013.

II

Setting & Context

The District of Puna is roughly the size of the Island of Kauaʻi and is located on the easternmost portion of the Island of Hawaiʻi. It borders the District of South Hilo to the north and the District of Kaʻū to the west. The geography of Puna is largely volcanic, a function of historic eruptions of Kīlauea and Mauna Loa. Puna is a stunningly beautiful area, dominated by a rugged coastline, thick rainforests, private residences, and fruit, flower, and vegetable farms.

Puna has never been densely populated and in ancient times, seems to have primarily been a thoroughfare between the more established areas of Kaʻū and Hilo. Forty-five percent of Hawaiʻi County's subdivided lots are in the Puna District. 52,500 of these were created between 1958 and 1973 during Hawaiʻi's development boom, most without public services like paved roads, mail delivery, water, and sewer. To date, about one-quarter of the lots have been developed, most residents rely on water catchment systems, and most have private cesspools and septic tanks on their properties. Many residents are, by preference, not connected to the electrical grid.

After Western contact, industry in Puna began with sandalwood, progressing to coffee and cattle, to diversified agriculture in the mid-1800s, to a vast sugar plantation in 1899, and then back again to coffee and diversified agriculture in the late 1980's. Today, although the natural and social environments are predominately rural and agricultural, less than 10% of the population is engaged in fishing, farming, or forestry. Nearly 70% of Puna's residents commute to Hilo to work or work from home.

In 2010, Puna's population was 45,326. Roughly a quarter of the population is under the age of nineteen with just under another quarter over age 60. Nearly 40% of Puna's people are first generation Hawaiʻi residents with a higher proportion of Caucasians (37%) and Hawaiians (11%), and considerably fewer Asians (16%) than the rest of the State. Puna has the third highest unemployment rate, the third lowest per capita income, and the highest percentage of families who rely on food

stamps (55%). Puna has a higher proportion of homeowners (68.2%) than both the County and State. Half of the Pāhoa population age 65 and older are living with disabilities. Approximately 85% of Hawai‘i Island's Section 8 low-income rental housing certificate holders are Puna residents. In 2000, the per capita income in Puna was 40% less than the State average. Between 2000 and 2010, Puna's population increased by 66%, the largest increase in Hawai‘i County. If trends continue, Puna's population is projected to grow to approximately 75,000 by 2030.

The Kīlauea East Rift Zone

Kīlauea, a highly active volcano, continues to shape the biogeography of the region and is a natural emitter of potentially dangerous gases and metals. It also creates some of the natural soil, air, and water conditions in Puna, which includes some of the metals and possibly some of the gases that are the focus of this report. For example, during portions of 2008, Kilauea was producing 4,000 tons/day and higher of SO_2 resulting in concentrations in air greater than 5,000 ppb in downwind communities within 31 miles of the volcano.

During its journey through the air, more often to the west and not towards Puna, SO_2 reacts with oxygen, sunlight, and water to form "vog," a mixture of gas and tiny sulfuric acid aerosol droplets. This aerosol mixture often appears as a dense haze that obscures Hawaiian scenery and ocean views. The acidic droplets in vog are small enough that they can be inhaled deep in the lungs and can pose health problems. In addition to the effects on living creatures, droplets can acidify rain and burn the leaves of plants, including many agricultural crops, such as protea, roses, fruits, and vegetables.

Carbon dioxide (CO_2) is the second-most abundant constituent in Kilauea emissions. CO_2 emission rates in 2008 were about 10,000 tons/day. Gaseous hydrogen fluoride (HF) is emitted at rates between 7 to 12 tons/day from Kīlauea and is therefore generally not a direct problem. However, fluoride deposited on the leaves of downwind vegetation and not metabolized by plants can be. Animals grazing on tainted forage can get fluorosis and ultimately die if fluoride amounts are high enough. About one ton/day, combined, of various metals, such as lead, copper, gold, silver, zinc, bismuth, and mercury are also emitted by Kilauea. The ongoing rift and summit eruptions of Kilauea produce between 4 to 10 tons/day of H2S, most of which reacts rapidly with SO2 to form water vapor and sulfur.

Puna sits atop Kilauea's East Rift, a 60-plus, mile-long zone of structural weakness extending from the surface to a depth of several miles and from Kīlauea Caldera to Cape Kumukahi and continuing off shore. Fed chiefly by Kilauea's summit magma reservoir, tabular-shaped magmatic dikes intermittently intrude upwards in

the rift zone, sometimes reaching the surface as an eruption, at other times stalling beneath the surface as intrusions. It is the energy from what some characterize as a "river of heat" that geothermal developers have sought to harness for electricity.

The geo-dynamics of Kilauea's East Rift Zone continues to be vigorously studied, but much is still unknown about the exact shape and extent of the subsurface magma bodies and precisely how they are fed from below. Magma moving within the rift zone exerts variable pressure on the cooler surrounding rock. This movement and the presence of underground heated bodies of water lying over magma result in earthquakes, tremors, and other seismic activity.

A preexisting, magma-filled passageway exists within the east rift zone. Magma can more easily and "quietly" move through a passageway with a molten core than through solid rock. Many scientists have conjectured that one or perhaps many coalescing dikes have formed a body of molten magma that serves as conduit beneath the rift zone. Such a molten core is probably centered three to four kilometers below the surface and extends as far as 30-40 km from the summit caldera. This subterranean horizontal passageway is likely no longer dike-like. Instead, it has probably widened by the melting and excavation of wall and roof rocks into wider passageways.

Geothermal Energy Development in Puna

Worldwide, three basic types of geothermal power plants are in operation: dry steam systems, flash systems, and binary systems. Dry steam, the oldest geothermal technology, takes steam from the ground and uses it to directly drive a turbine. Flash plants tap deep, high-pressure hot water that "flashes" into steam as pressure is reduced. The steam is used to drive a turbine.

In binary cycle geothermal power generation, steam from a geothermal reservoir never comes in contact with the turbine units. Low- to moderately-hot fluids heat a secondary fluid with a much lower boiling point that then travels through a heat exchanger. Heat from the geothermal fluid drives the turbines and subsequently, the generators. Binary cycle power plants are closed-loop systems. Geothermal power plants can also be a hybrid of these three basic types. PGV, for instance, incorporates both binary and flash technologies in a closed-loop system.

Geothermal energy developments on Hawai'i Island have proceeded in three phases: initial research and assessment, experimentation, and commercialization. In 1961, the Kapoho Land and Development Co drilled four shallow exploratory test wells in Puna. At depths of 200 and 700 feet, no viable resource was found.

In the early 1970s, the Hawai‘i Geothermal Project was initiated by the UH and the U.S. Geological Survey to undertake more systematic research into geothermal resources. Geophysical characterization, groundwater geochemistry, engineering, and environmental-socioeconomic research began in earnest.

By 1976, the HGP-A well was completed. HGP-A was a flash system. At 6,455 feet deep with a maximum down-hole temperature of 676°F, it was among the hottest wells ever known. The Hawai‘i Institute of Geophysics was awarded a grant by the U.S. Department of Energy in 1978 to conduct a statewide geothermal resources assessment program. A series of reports was issued that described the varied potential for geothermal development on the major Hawaiian Islands.

After strong objections to releases of H2S from the neighbors of HGP-A, a H2S abatement system was constructed for the HGP-A well. Further well testing was conducted to provide data for the design of a 3.5 MW wellhead generator facility that would test the long-term viability of the geothermal resource. This was completed in 1981. Barnwell Geothermal and Thermal Power Company drilled exploratory wells near HGP-A (Kapoho State 1, 2, & 1A). The Ashida and Lanipuna wells, drilled south of the rift zone, reached 8,400 feet but failed to demonstrate a viable resource. They were plugged and abandoned. The Kapoho State (KS) wells were able to sustain steam flow and demonstrated that a viable resource existed beyond the HGP-A well.

Meanwhile, the 3.5 MW HGP-A demonstration power plant began continuous operations in 1982 and provided approximately 3 MW of power to the Hawai‘i Island grid. The private and publicly funded project was intended to demonstrate the technical, environmental, and economic feasibility of the area’s geothermal resources. In 1985, it was decided to continue its operation until a commercial plant could come online. However, power production was terminated in 1989 due to inadequate maintenance, poor effluent disposal and abatement, and unreliability and safety concerns about the well casing.

Between 1984 and 2012, wells were drilled by the successor to Thermal Power Company, PGV. From 1989 to 2004, PGV was owned and operated by Constellation Energy. Inc. but in June 2004 PGV was purchased by Ormat Nevada, Inc. Headquartered in Nevada, Ormat Technologies, Inc. is the current owner and operator of PGV.

Presently, four of the wells are used for injection: KS1A, KS3, KS11, and KS13. Five are used for production: KS5, KS6, KS9, KS10, and KS14. KS15 is expected to become a production well. There are also three monitoring wells onsite, one of which provides non-potable water for operations. The remaining wells have been

plugged. PGV is a combined flash and binary system. It is designed to be a closed-loop system that draws fluids up to drive turbines, and then re-injects those fluids back into the earth.

In 1986, Hawai‘i’s BLNR approved True/Mid-Pacific Venture’s exploration for up to 100 MW of geothermal energy and the development of up to 25 MW for the purpose of generating power for the Island of Hawai‘i. Additional megawatts of capacity were to be approved in increments. The CDUP was subject to 34 conditions. The County of Hawai‘i Planning Commission also adopted Rule 12 regulating geothermal development in agricultural, rural, and urban land use districts (“Geothermal Resource Permit”). That same year HELCO announced the conclusion of a power purchase agreement for 25 MW with PGV.

In 1989, PGV received a Geothermal Resource Permit (GRP #2, 87-1) from Hawai‘i County for 25 MW of net generated energy. This included 10 integrated back-pressure steam turbine and air-cooled binary cycle turbine power generating modules, up to 30 geothermal wells drilled from six well pads, and other infrastructure development including pipelines, a switchyard, warehouses, and access roads. There were 50 conditions to the permit. In 1989 drilling also began on three publically funded Scientific Observation Holes (aka “slim holes” or “core holes”) under the direction of the UH to provide geologic samples and thermal data across the lower half of the Kilauea East Rift Zone. Depths of the test holes ranged from 5,500-6,800 feet and temperatures were noted as high as 660°F.

In 1990 after legal objections and court proceedings, the State of Hawai‘i DOH issued air permits to PGV for the construction of a 25 MW power plant and geothermal well field. The air permits required the installation of three ambient air monitoring stations to measure concentrations of H2S in neighborhoods near PGV and on the fence line surrounding the power plant. Following a lawsuit initiated by community members against DOH, the State established legal H2S limits of 25 ppb for a one-hour average and 10 ppb for a 24-hour average.

The protection of underground sources of drinking water is regulated through permits issued by DOH on behalf of EPA. Between 1992 and 1995, a groundwater-monitoring program was initiated for several shallow groundwater wells in Lower Puna to determine the impact of commercial drilling and production on the groundwater system.

Under Hawai‘i County Geothermal Resource Permit (GRP-1), PGV developed the resource and began operation in 1993. Under this permit, noise levels were not to exceed 45 dB at night and 55 dB during the day. However, three years later in 1996, DOH implemented statewide noise rules. According to those new rules,

PGV was allowed up to 70 dB as measured at the property line. In 2001 PGV obtained an amended Geothermal Resource Permit from Hawai‘i County, allowing an increase of generation to 60 MW with incorporation of updated regulatory standards and permit requirements.

During drilling operations at well KS13 in 2005, PGV encountered magma at a depth of 8,163 feet. The well was successfully completed and serves as an injection well. One year later, PGV obtained an amendment to its Plan of Operations regarding Geothermal Resources Mining Lease R-2 from DLNR. Fourteen wells (in addition to the original 14 wells) were approved for future expansion to 60 MW. A year later, Hawai‘i County completed a study of the feasibility of direct uses of geothermal energy funded by the U.S. Department of Energy. Candidate applications included greenhouse bottom heating, pasteurization of potting media, biodiesel production, and lumber drying.

In 2011 UH was awarded a grant by the U.S. Department of Energy to develop advanced technologies for identifying geothermal resources and determining fluid flow within hydrothermal systems. Additional funding was provided from State agencies to allow the project to conduct a broader survey of prospective geothermal resources throughout the State using modern state-of-the-art technology. UH will conduct magnetotelluric surveys to characterize geologic structures that are predicted to host geothermal resources.

In 2011, HELCO released a Request for Information seeking input on expanding geothermal energy on Hawai‘i Island. The year following, PGV added 8 MW of power. With the passage of Act 97 in 2012, the Hawai‘i State Legislature eliminated the designation of geothermal subzones from State statute. Because the County’s Geothermal Resource Permits were tied to that statute, the process for the permits was also eliminated. This year, 2013, HELCO released an RFP for 50 MW of geothermal energy.

Environment & Health Problems

Oversight of health matters relating to geothermal energy production in Puna is conducted by different government agencies. The protection of underground sources of drinking water is overseen through permits issued by DOH on behalf of EPA. Air quality and noise are regulated by DOH. DLNR regulates drilling and reservoir management. Some aspects of land use and all emergency response systems are the domain of County of Hawai‘i.

PGV maintains three air monitoring stations on its property as well as several dozen additional fixed and portable monitoring detectors. Consultants reporting to PGV monitor geothermal fluids coming up through production wells along with other chemicals that may be entering the air or water. DOH originally established three air-monitoring stations beyond PGV's property. Two of those were later removed for budget reasons when they had shown no elevated levels of H2S.

From the beginning, the exploration and commercialization of geothermal energy development in Hawai‘i has experienced problems, most of them associated with H2S and noise. As early as 1977 a flow test of HGP-A was terminated due to complaints over H2S emissions. The most troublesome problem took place in June, 1991 during the drilling of KS-8. A high-temperature, high-pressure zone was encountered at a depth of 3,488 feet. When this zone was penetrated, a powerful steam-driven pressure pulse rapidly moved up the well bore impacting surface equipment and damaging parts of the blowout prevention equipment and drill rig. The well continued to produce a strong flow of geothermal steam, brine, and gas through the damaged blowout prevention equipment. The flow continued for approximately 31 hours before control of the well was reestablished.

This event, referred to as "the blowout," released an estimated 200,000 pounds per hour of steam and brine containing 180 pounds per hour of H2S in a complex plume cloud which was estimated to have emissions extending from ground level to a height of 65 feet. In addition to H2S, the plume contained elements of lead, nickel, cadmium, mercury, other metals, and dissolved solids, which are also naturally present in ground and drinking water. It is unclear to what extent this airborne plume definitively affected downwind residents. However, a third-party investigative team reported in July 1991 to then-Hawai‘i County Mayor Lorraine Inouye and then-BLNR Chairperson William Paty that the blowout occurred because of inadequacies in PGV's drilling plan and procedures, not as the result of unusual or unmanageable subsurface geologic or hydrologic conditions.

Also in 1991, the U.S. District Court in *Blue Ocean Preservation Society v. James D. Watkins (D. Haw. 1991*) ruled that plaintiffs Blue Ocean, Sierra Club, and Greenpeace were entitled to a permanent injunction prohibiting the government from participating in the Hawai‘i Geothermal Project until a federal Environmental Impact Statement (EIS) was complete. Since the first two phases had been completed by then, only Phases III and IV were affected: a resource verification and characterization program and the construction of 500 MW of geothermal power plus an underwater cable.

In 1992, DOH performed a health risk assessment on the potential adverse health effects from short-term exposure to H2S resulting from the blowout. This appears to

have been a telephone survey done by DOH with questionnaires distributed by the Big Island Rainforest Action Group. No meaningful epidemiological data were obtained. However, the survey provided insight into some specific health grievances, three of which warranted further behavioral and respiratory investigation.

In 1995, Sierra Club Legal Defense Fund filed a lawsuit against the State of Hawai‘i and County of Hawai‘i. Plaintiffs included the Big Island Rainforest Action Group, Greenpeace, Pele Defense Fund, and Sierra Club. They alleged that defendants had violated Chapter 343, Hawai‘i Revised Statutes regarding the Hawai‘i Deep Water Cable Program, known in the suit as the Large-Scale Geothermal/Cable Project. The settlement terminated State participation in the project and ended State support for the groundwater monitoring program in Lower Puna.

In 1996, EPA published a report of their PGV Compliance Investigation. At the request of EPA Region 9, the National Enforcement Investigations Center conducted a compliance investigation of PGV. The investigation's objectives were to confirm compliance with air pollution control regulations, underground injection control regulations, Emergency Planning and Community Right-to-Know Act, Comprehensive Environmental Response, and the Compensation and Liability Act. The report listed areas of non-compliance, areas of concern, and outlined recommendations for changes to permits.

The following year, 1997, the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry responded to a request from DOH and performed a health consultation to assess the threat to public health posed by releases of H2S from PGV. Relying only on the monitoring station at Lava Tree State Park 1.5 miles away from PGV, ATSDR concluded that the concentrations of H2S in residential areas near the PGV did not pose a public health hazard.

Since the blowout, DOH has recorded six incidents when permitted H2S limits were exceeded by PGV, including KS8 well drilling, well clean out activities, seal leaks, and equipment malfunctions. The one-hour limits ranged from 31 ppb to 789 ppb with the permit limit being 25 ppb on a one-hour average. Fines totaling $55,200 were assessed. These violations occurred from 1991 to 2005. As of February, 2013 PGV has reported 70 upset conditions involving H2S, 41 of which resulted in written reports to DOH, 28 involved verbal or courtesy notifications, and one resulted in a permit violation for exceeding the 25 ppb hourly average.

The development of geothermal energy has been the subject of numerous lawsuits and there is a complex litigation history. A number of suits (and their appeals) focused on land use, Native Hawaiian rights, and the oversight duties of State and

federal agencies. Seven tort cases with multiple plaintiffs alleging health damages were also filed in the 1990s.

- 30 plaintiffs filed suit in *Robert Petricci et al. vs. Puna Geothermal Venture et al.* (Civil No. 91-0-0324, July 23, 1991)

- 30 plaintiffs filed suit in *Monica Boyd et al. vs. Puna Geothermal Venture et al.* (Civil No. 91-0-0356, August 6, 1991)

- 27 plaintiffs filed suit in *Cyntha Ann Bryan et al. vs. Puna Geothermal Venture et al.* (Civil No. 91-0-0381, August 26, 1991)

- 20 plaintiffs filed suit in *Adam Ayala et. al. vs. Puna Geothermal Venture et al.* (Civil No. 91-0-0481, October 24, 1991)

- 7 plaintiffs filed suit in *John Keeney et al. vs. Puna Geothermal Venture et al.* (Civil No. 92-0-0177, April 21, 1992)

- 12 plaintiffs filed suit in *Thomas Brennon et al. vs. Puna Geothermal Venture et al.* (Civil No. 91-0-0348, June 9, 1993)

All of the cases with multiple plaintiffs were settled for undisclosed amounts. Of the 118 plaintiffs, one case, *Maureen Gap v. Puna Geothermal Venture*, sought damages for acute asthma alleged to be caused by PGV. A summary judgment was issued in favor of PGV.

III

The Issues

Joint fact finding requires visiting, revisiting, and sharpening the fundamental questions in a way that can, to the greatest extent possible, be informed empirically. This means taking different, sometimes successive, "passes" at the questions brought forward by Study Group members and the public, the data sets available to the group, and the peer-reviewed and non-peer-reviewed scientific studies on record.

First Pass ~ Initial Questions

Initially in what would be considered a "first pass," the Study Group sought to organize its deliberations around the three central deliverables requested by the Mayor. The exact framing of the Study Group's inquiry is contained in the Project Description (Annex-1). At the onset of the Study Group's meetings, these translated to the following:

- What evidence is there of possible negative health effects linked to geothermal energy production?
- What are the significant questions that require further information or more evidence?
- What specific effects have been seen, how significant are they in terms of intensity or geographic spread, who appears to be affected, and what indicators reflect this?
- Which concerns and risks are most worrisome, and where do the risks and concerns stand in priority with each other?
- What criteria should be used to evaluate the strength of different studies and data sets?

- What specific empirical studies or data sets should be included in the annotated reference collection that will be useful to the County and the public, and how should the collection be organized?

- What indicators of health conditions should be monitored?

- What specific future studies are needed and in what priority?

- What issues should be considered when future health studies are developed, e.g., physical variables, geographical regions, future usefulness, etc.?

Second Pass ~ High Priority Questions

In a later discussion, and having heard from some members of the public, treating clinicians, and other experts, the group more explicitly sought to isolate the highest priority questions that must ultimately be answered regarding monitoring, exposures, and recommended health studies. In essence, the Study Group sought to acknowledge, categorize, crisply articulate, and then examine to the greatest extent possible the health and safety fears expressed by some members of the public, many of these brought forward by Puna Pono Alliance. The Study Group's highest priority questions evolved to the following:

1. **Exposure & Monitoring**

    a. Past and Current Monitoring. Since the 1991 blowout, how adequate and accurate has the monitoring of air, water, and ground exposure been?

    b. Future Monitoring. What air, water, and ground monitoring regimes need to be put into place going forward?

2. **Health**

    a. Neurological and Cognitive Function. Has normally healthy brain function been affected from either acute or chronic exposures?

    b. Respiratory and Cardiac Function. Have normally healthy respiratory and circulatory functions been affected by either acute or chronic exposures?

    c. Reproductive Function. Have normally healthy reproductive, fetal and neo-natal functions been affected by acute or chronic exposures?

d. Psychological Function. Have normally healthy behavioral functions been affected by acute or chronic exposures?

3. **Incident Response, Alert, Evacuation**

a. Past and Current Alerts. How adequate have the County and State's past incident response, alert, and evacuation systems functioned and how well do they function now?

b. Future Alerts. What specific changes can be made to improve the incident response, alert, and evacuation systems going forward?

Third Pass ~ Additional Questions

The following more specific questions, copied verbatim from a Study Group session meeting, suggested further inquiry and possible methodological considerations.

- Are there significant statistical differences in "well-being" as measured by accepted, certified survey tools in comparison to populations similar in demographics, sociological characteristics, and medical histories living in areas with similar natural volcanic emissions and power plant emissions?

- What are the impacts of geothermal air, water, and ground emission effects on the human central nervous system, pulmonary functions, and other organs and systems?

- Caustic soda is used to minimize hydrogen sulfide. What are caustic soda's effects on health?

- Have HGP-A and PGV, now and in the past, handled all hazardous waste streams in a completely legal and transparent manner?

- What have been the psychological and stress effects of geothermal energy production and exploration?

- What have been the psychological impacts to the community, i.e., anxiety disorders, insomnia, depression, and PTSD? Are there long-term psychological impacts of living next to geothermal power plants in Hawai'i?

- Are there significant statistical differences in stress-related illness as measured by blood chemistry (e.g., cortisols, catecholamines), neurobehavioral, physiological, and psychological function and other medical tests due to noise or vibrations among populations similar to Puna?

- Why weren't the Goddard & Goddard report recommendations put in place?

- Is geothermal energy production introducing contaminants into the atmosphere, and if so, to what level, in which direction do they flow, and how far do they travel under various conditions?

- Are there statistical differences in respiratory illnesses as measured by quantified respiration deficiencies, neurobehavioral function, and other medical or physiological tests?

- What are the long-term impacts of chronic, low-level exposure to geothermal energy production chemicals and emissions including H2S and other toxins?

- What are the cumulative impacts of geothermal energy production on the surrounding community?

- Can we monitor low-level H2S exposures? Can we get a baseline?

- Are there significant statistical differences in chronic effects of H2S (or other documented emissions from the blowout) on known medical effects as measured by quantified neurological and physiological function loss among populations similar in demographics, sociological characteristics, and medical histories that are living in areas similar to Puna?

- How do we devise an adequate evacuation and alarm system to ensure the safety of the community in the event of a blowout or another catastrophic event in lower Puna, i.e., earthquake, volcanic flow?

- What is the emergency response system used by HCCD, Police, Fire Dept., etc.?

- What have been the in-utero effects of geothermal energy production and exploration? What are geothermal energy production effects on fetal and neonatal development?

- Has the water in Puna been affected and is it safe for public use? Examples: warm ponds, Champagne ponds, wells, and catchment systems.

- Can we monitor ground water flows and establish a baseline?

- What is the disposition of liquid and solid effluent from HGP-A and other exploratory geothermal energy production studies?

- How does wind, seismicity, and volcanic activity increase the risk to communities close to geothermal?

- Are there cancer risks from geothermal energy production?

- Is the current technology in use at the plant considered "state of the art" or BACT?

- Are individuals within the various government agencies tasked with oversight prepared and willing to do it?

- Of those living and working within five miles of the existing plant, what percentage thinks that geothermal energy production is a big problem for them?

- How many in Puna think that geothermal energy production can be a good neighbor and how many think it can never be?

- Can we know the full acute and chronic health effects of the Puna community if precise exposure to H2S and other geo emissions is poorly understood.

IV

General Findings

The sole focus of the Study Group has been a search for insight as to what health stressors have been created by geothermal energy production in Puna and what effects have ensued. Alerted by complaints and testimonies from the community, reports from previous experts who have studied geothermal health issues, information on incidents, hazards, and exposures, and an examination of some of the pertinent scientific literature, the Study Group has sought to understand the quantitative and empirical evidence that exists regarding health harms:

- What do we know about the baseline health of Puna?
- What actual complaints have been made?
- Who is being, or has been, exposed to what, who has actually been hurt, in what ways, and are there other empirical or epidemiological factors that might account for baseline health and complaints?

The Study Group makes three findings.

1 Puna's public health profile is unclear

Puna's overall public health appears worse than the County and State as a whole. We do not have an accurate and readily available profile of disease and illness patterns for the past and current populations of Puna, and more particularly, for Lower Puna. A health profile could provide a better basis for understanding geothermal health issues. Usable and pertinent public health information should normally include statistics on mortality (heart disease, malignant neoplasms, cerebrovascular disease, respiratory illness, unintentional accidents, etc.); actual causes of death (accidents, tobacco, alcohol, microbial agents, toxic agents, etc.); actual disabilities (arthritis, diabetes, chronic back problems, impaired vision, etc.); and detailed mortality and morbidity information by age, ethnicity, and length of time in Puna. An accurate health picture should normally also include clinic and hospital admissions, numbers of days of sickness, and other statistical snapshots.

Discussion

Puna has unique challenges. Being a rural area with a highly dispersed population and underdeveloped transportation and health systems, it is difficult for residents in need of health assistance to reach help. There are clinics but no hospital facilities in the District of Puna. There are no public wastewater treatment systems; most homes have septic tanks or cesspools. About 13% of Puna's people live below the federal poverty line. Almost half of the population age 65 and over are living with disabilities. Puna has the worst statistics in the County for low birth weight babies (9%), mood disorders (1,885 over a 5-year period, or 10%), and anxiety disorders (790 over a 5-year period or 4.6%).

While 84.2% of Puna's population report themselves to be in good health, other numbers suggest problems. Seven percent of the population lack complete plumbing facilities and four percent lack complete kitchen facilities. Puna's high percentage of low-income residents tends to increase the need for social services, yet private health care providers are reported to be reluctant to locate in Puna due to insurance issues. Puna residents score worst in the state on several other indicators: adults who are obese (24%); adults who smoke (18.9%); adults without health insurance (9.5%).

The "State of Hawai'i's Primary Care Needs Assessment Data Book 2012" supports the Study Group's assumption that Puna's baseline health condition lags behind the rest of Hawai'i Island and much of the state. Puna also may suffer greater numbers of respiratory problems than other local populations. This could be caused by molds, pollens, spores, or to exposures from sulfur compounds like H2S or SO2 and/or their interaction with particulate matter. As compared to other communities on the island or in the State of Hawai'i, access to doctors, hospitals, and government services in Puna has been and continues to be less than it should be. On the other hand, the Study Group is cognizant at least anecdotally, that many Puna residents pursue alternative lifestyles both in their desire for rural, away-from-the-city independence and in their preferences for alternative health care providers, of which there are many in Lower Puna.

2 Health studies are needed

Events during the HGP-A era and during the 1991 blowout provided exposures associated with adverse health effects. This knowledge, along with other information contained in this report and referenced in Annexes-3 and -4 has led the Study Group to conclude there is evidence that there were health effects from the exposures

during the development of geothermal before 1993. The full extent and severity of those effects has not been documented.

After 1993, the Study Group is less certain about whether there have been health effects and what the extent and severity of the effects might be. In 1996, Dr. Marvin Legator conducted a study of Puna residents that showed significantly higher adverse health effects normally associated with industrial H2S than three reference communities.

Discussion

An early part of the Study Group's effort involved an attempt to inventory actual health complaints and attributions made about HGP-A and PGV. This required included gathering information from different sources.

During initial interviews done by Peter Adler prior to the formation of the Study Group, interviewees from the community, the County, and local medical practitioners reported experiencing or hearing about respiratory and pulmonary problems; skin rashes; lesions; cognitive disorders; reproductive problems; and stress. Embedded in these interviews was the further question as to whether there is empirical evidence of illness or disease "clusters." Some of the reports cited in the interviews were by Doctors Kilburn, Kurohara, Legator, Ruben, and Sherman.

H2S is a known toxicant that interacts with human enzymes and macromolecules like hemoglobin and myoglobin with well-documented detrimental effects. Many organs are susceptible to injury, especially those with exposed mucus membranes and higher oxygen demands. CNS neurotoxicity and pulmonary edema are well-documented consequences of higher exposures.

Enduring and cumulative harms from lower-level exposures over time is still being studied and debated, but the harms may be more damaging than previously thought. H2S exposure can involve, among other symptoms, cardiovascular and gastrointestinal disturbances. Respiratory symptoms may include shortness of breath, bronchitis, and pneumonia. Blood-related symptoms might include easy bruising, abnormal blood counts, anemia, or clotting disorders. CNS effects can include fatigue, restlessness, sensory imbalances, headaches, short-term memory loss, depression, and anxiety.

Geothermal energy production is in conflict with the religious and cultural beliefs of some Native Hawaiians and Pele Practitioners. Although Westerners and many others see land, water, air and underground energy as a resource to be responsibly used and managed, some Native Hawaiian beliefs hold the land, or ʻaina, as sacred

and consider humans to be stewards of the ʻaina. Other Native Hawaiians believe man can thrive and prosper but desecration of the ʻaina leads to lack of health for everyone. Still others believe the two can be done if done properly.

Geothermal development as a possible stressor to Native Hawaiians' religious and cultural values has not been examined in the various geothermal impact assessments done by DOH, EPA, Legator, Sherman, Ruben, or Goddard & Goddard. As a result, it is not clear how geothermal development affects traditional Native Hawaiian practitioners, psychologically or physically.

Other issues related to the need for health studies:

1 Meeting with Treating Physicians

At its second meeting, the Study Group spoke with Drs. Sherman, Ruben, Dundas, and Kilburn and reviewed some of the materials provided by them and by the DOH. No report from Dr. Kurohara could be located. Sherman, Ruben, and Kilburn reported that they had treated health conditions they believed attributable to geothermal energy production, primarily from the 1991 blowout.

2 Complaints to PGV

Keala Carter, a member of Adler's project team, conducted a random sampling of some 400 complaints recorded from the PGV hotline between 1992 and 2010 (complaint log for 2006 was missing). Her examination showed the overwhelming majority of complaints were noise-related--three to four times the amount of any other complaint. Second was the number of complaints about bad smells emitted from the plant, presumably H2S. Sour smell complaints appeared to come in groups of one- to three-day periods with long periods in between. In the sampling done by Carter, the early 1990s showed the greatest number of smell-related complaints. As smell-related complaints seemed to wane, noise and stress-related complaints seemed to increase. Most of the complaints relate directly to plant operations, and the history appears consistent with plant activities that were occurring at the time of the complaints.

3 Complaints to Council

Carter also reviewed twelve relocation requests at the Department of Planning and complaints submitted in council testimony. One relocation request contained a documented health history of visits to a doctor and a hospital over the course of two and one-half years. In addition to bronchitis and asthma, the individual reported suffering from a variety of maladies including back pain, dizziness, and heart palpitations. Two other relocation requests referenced health issues but did

not specify from what issues the individual and/or family was suffering. The reasons usually given for relocation requests were noise, smell, stress, and fear for safety living in close proximity to a geothermal energy production plant.

In a review of approximately 240 health-related testimonies attributing causes to PGV, many but not all were found to be second-hand accounts, i.e., "my friend has been ill…" or "I know someone who…" or "there are a lot of people with health issues in the area." There were also first hand accounts from the community about health effects related to geothermal operations. The firsthand accounts of illness often focused on noise emanating from the plant resulting in stress and sleep disturbance. Repeated fears were voiced about the potential for negative health effects and reactions to possibly toxic surroundings. A recurring theme in testimony was the desire for a public health study to determine, once and for all, the condition of the people and environment near PGV and adjacent communities.

4 Women's Health Group

A women's group made up of Puna residents was assembled by community members in 2012 to examine possible links of health problems that might potentially be attributable to PGV. Twenty-one Puna women between the ages of 24 and 71 completed surveys in June 2012, and data were hand tabulated. The self-reporting survey examined general medical histories and conditions, the use of over-the-counter medications, allergies, and various medical diagnostic tests that had been taken. Respondents were asked to rate their general health, and responded as follows: 4 excellent, 13 good, 3 fair, 1 poor. The study also examined exercise, special diets, and reported histories of smoking and alcohol consumption. The study made no attempt to provide specific interpretations or correlations as to possible health links with geothermal energy production.

5 Department of Health

In 1984 and in response to geothermal attributed complaints, State of Hawai'i's Healthy Start Program conducted a study of the health status of several Puna geographic sub-populations exposed to H2S and other geothermal emissions. Overall, the rates of acute and chronic health issues, including chronic respiratory issues like bronchitis, emphysema, asthma, hay fever, sinusitis, and other respiratory system diseases, were higher in both Leilani Estates and Hawaiian Beaches than the County and State as a whole.

The similar rates in the two communities were conspicuous because chronic respiratory conditions are symptoms most often associated with long-term

exposure to air pollutants. The study went on to say that the presence of natural volcanic vents in the vicinity makes it difficult to determine what contribution the presence of geothermal energy production has on the air quality and corresponding health issues. The study was inconclusive. It could not be determined that H2S produced from geothermal development was responsible for any of the health conditions reported in Leilani Estates or Hawaiian Beaches.

6 Goddard & Goddard Report

Following the 1991 blowout, Goddard & Goddard Engineering was commissioned by the State to undertake an environmental analysis. Three sets of data were reported, gathered by the Big Island Rain Forest Action Group, the Kapoho Community Association, and community member Colleen Mandala. Respondents in all of the communities surveyed reported experiencing excessive noise, sulfur odors, eye irritations, and trouble breathing. Some individuals required medical care. Estimating the exposures that were received and evaluating the reported effects, Goddard & Goddard concluded that high levels of gaseous toxic concentrations added to other heavy metals, aerosols, and particulates are estimated to have given rise to the reported 123 adverse health effects.

7 The Legator Study

In 2001, Dr. Marvin Legator published a study based on testing done in 1996 and 1997. This study showed that Puna residents had significantly higher adverse health effects normally associated with industrial H2S than three reference communities. He recommended further study be done. Because Dr. Legator partially relied on volunteers rather than a complete randomized sample, the State DOH criticized the methodology for this study.

8 Other Complaint Sources

Several members of the Study Group believe that formal complaints, grievances, and reported medical symptoms lodged with PGV, the State, and the County are the proverbial "tip" of an iceberg. They believe many more complaints go unreported due to distrust and cynicism about the government's response, because of a preference for traditional or alternative medicine practitioners, and because CNS impacts are especially subtle, insufficiently documented, and may either go unnoticed or be attributed to other causes, such as aging. Complaints of injury have been listed in tort litigation cases against PGV by community members and by former employees. More recently, the Puna Pono Alliance has created a web site where individuals are able to register health complaints they attribute to geothermal energy production. The results of their registry are unknown.

3 Geothermal operations carry health risks

Risks from geothermal energy production in Lower Puna exist. The actual extent and impacts of those risks remains unresolved. What is known is that hazardous chemicals are brought up by PGV. PGV adds industrial chemicals to the mix in the process, and then sends the composite fluid back down. However, fluids inevitably escape to air, water, or at surface level. Harmful effects can only be understood through better monitoring and reliable health data.

Discussion

The EPA views "risk" as the chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental stressor. For our purposes, we assume risk to be a combination of "hazard," "exposure," "probability," and "vulnerability."

- Hazard refers to the inherent properties of the chemicals and mechanical operating processes.

- Exposure is actual contact and interaction with a hazard over time, by location, and by a population. Toxicologists and chemists say, "the dose is the poison," so exposure information is especially critical.

- Probability is a measure of experience or expectation that an exposure has happened or will occur.

- Vulnerability is a measure, or at least a grounded estimate, of whom generally or who in specific subpopulations, may be endangered by possible exposure to a hazard. Vulnerability involves who is, or has been, or may be harmed; how many people have been harmed; and whether the harms have been short-term, long-term, annoying, debilitating, or fatal.

The "totality" of risks that may have been or currently are occurring from combinations of chemicals and operating processes has presented a unique challenge in relation to possible neurological or behavioral harms. Scientifically, it is difficult to understand what the amplifying or dampening effects may be when chemical exposures combine in the air or water. It is further unclear how these may combine with operational impacts like noise and vibration, the use of modifying chemicals like caustic soda, the risks of seismic activity, ambient or unusual geological and meteorological conditions, and atmospheric and topographic considerations from Puna's volcanic geography.

1 Hazards

Puna's location on an active volcanic rift carries natural volcanic hazards from earthquakes, lava flows, and gases emitted from fractures and fumaroles. Geothermal energy production entails additional chemical and mechanical hazards. H2S is one, and the primary focus 0f the Study Group's work. Other gases like SO2 and radon are also present. Metals like lead, arsenic, cadmium, chromium, and selenium are also present in geothermal fluids as is silica. Many of these may also be naturally occurring. Pentane, which is highly flammable, is used on site operationally as a heat transfer fluid. Caustic soda is employed by PGV to neutralize the effects of H2S during emergency bypass procedures. Other hazardous chemicals are used on site to clean and service the equipment. Still others are added to the geothermal brine such as anti-scaling products.

Industrial geothermal energy production also involves both ambient noise and episodically higher decibel levels of noise, especially when drilling takes place. Ground vibration occurs. Lastly, any industrial operation entails potential "life and limb" hazards from explosions, and accidents.

2 Exposures

Hazard information by itself is inadequate for understanding the type and intensity of possible health harms that may have occurred, may be occurring now, or may occur in the future. The Study Group has tried to gather exposure information on H2S, caustic soda, pentane, and various metals, especially H2S. The most reliable exposure information comes from the 1991 blowout. Using USGS data from PGV KS 8, H2S exposures were measured at approximately 1,680 ppb about one-half mile from KS8, which is considered to be "above health significant levels" by Goddard & Goddard Engineering, authors of what the Study Group considers the most valuable post-blowout report.

On a more routine basis, emissions from an H2S emitting source, whether high but short-lived, constant low level, or cumulative do not automatically equal exposures. Exposures are heavily influenced by plume characteristics, average and peak durations of concentrations, atmospheric conditions, topography, humidity, and other meteorological and geographic factors. Because wind speeds and directions vary, data for the 1991 uncontrolled event and other minor upset conditions are not scientific or statistically relevant enough for future modeling or decision-making though Christopher Biltoff has suggested a possible model (see Annex-4).

The Study Group has struggled to acquire solid exposure information that could then be coupled to information about inherent hazards, event probabilities, and reasonable inferences about the past. Data have been provided by PGV and the State, but that information is viewed as incomplete and some of it is contested. Specifically, the mass of chemicals released during all incidents is unavailable. Are records accurate? Were there enough monitors? Were they placed and positioned correctly? Were they properly calibrated?

3 Probabilities

Based on reports of attending physicians, estimated exposures, personal reports, and the Goddard & Goddard study, it is likely that health harms occurred between 1981 and 1989 during the HGP-A project as well as the 1991 blowout. For other events, determining reliable exposure information is more difficult. The specific permanent or transient damage that might have occurred or that may, through further exposures, create cumulative effects, has not been systematically studied. Additionally, few studies have answered important questions about the effects of low-level, long-term exposure to H2S. Ongoing scientific research should provide insight about these effects.

4 Vulnerabilities

For the population at large, vulnerability information is available for many chemicals, much of it published by the EPA. Interestingly, the EPA has never set a real standard for H2S. However, the EPA has published acute exposure guidelines, or AEGLs, as follows:

Hydrogen sulfide 7783-06-4 (Level of Odor Awareness = 0.01 ppm)					
ppm					
	10 min	30 min	60 min	4 hr	8 hr
AEGL 1	0.75	0.60	0.51	0.36	0.33
AEGL 2	41	32	27	20	17
AEGL 3	76	59	50	37	31

On this chart, “AEGL-1” is the airborne concentration, expressed as parts per million (ppm) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

"AEGL-2" is the airborne concentration (expressed as ppm) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

"AEGL-3" is the airborne concentration (expressed as ppm) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

(To translate EPA's numbers from ppm to ppb, which is used more consistently in this report, multiply EPA's numbers by 1,000.)

Airborne concentrations below AEGL-1 represent exposure levels that can produce mild and progressively increasing but transient and non-disabling odor, taste, and sensory irritation or certain asymptomatic non-sensory adverse effects. With increasing airborne concentrations above each AEGL, there is a progressive increase in the likelihood of occurrence and the severity of effects described for each corresponding AEGL. Although the AEGL values represent threshold levels for the general public, including susceptible subpopulations such as infants, children, the elderly, persons with asthma, and those with other illnesses, it is recognized that individuals, subject to idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL.

V

Recommendations

1 Undertake a comprehensive health effects study

Using robust scientific methodologies, the County should commission a comparison group study to test four hypotheses:

A CNS degradation of the sample population will likely be more pronounced as a function of highest peak exposure to H2S. Other symptoms, particularly respiratory effects, may be more pronounced as a function of length and extent of exposure, as well as time since exposure.

B CNS and other negative health effects from exposure to emissions including H2S will be greater in areas of highest exposures. Such exposures will be a function of meteorological conditions and emission rates over plant history.

C Heavy metal and other chemical contamination from geothermal energy production sources may have spread into the soil and into water catchments and affected drinking water supplies. This spread of heavy metals could cause health effects to residents in proximity to geothermal plants.

D As a consequence of noise and vibration, residents who have (a) lived closest to geothermal project development; (b) directly experienced geothermal gas releases; (c) have been evacuated; (d) or have experienced the highest noise and vibration levels may be more likely to show anxiety disorder symptoms.

Discussion

For the Study Group, understanding past, current, and possible future health harms, most especially from H2S, has come down to understanding two kinds of data and information: (1) what we know and what we conjecture about exposures and (2) what we know and what we conjecture about H2S and its health effects, especially at lower

or accumulating concentrations. In great part, this second understanding comes down to what is reasonably settled science versus science that is still evolving.

The Study Group spent a considerable amount of time seeking to understand the state of knowledge about short-term exposures such as those in EPA's AEGLs and long-term lower (less than 1000 ppb) exposures to H2S. Some aspects – the effects of exposures above 1000 ppb, for example -- are mostly settled. Others – the cumulative impacts of repeated or extended exposures at lower levels – are not. In scientific studies, question framing, hypothesis generation, variability in methods, selection of subjects including sub-populations, sample sizes, test standardizations, hypotheses bias, and covariates are critical.

1 Hydrogen Sulfide Impacts

Historical information about H2S exposure in Puna is incomplete, especially during the time of HGP-A operations. But even following the HGP-A era, monitoring has been insufficient to determine exposures of the people who lived proximate to the geothermal plant for four reasons.

A During plant upsets and incidents, regulatory agencies do not seem to have required that the amount of fugitive emissions released be calculated. The EPA Compliance Inspection suggested that the mass of H2S be determined for each incident. PGV does not appear to believe this is a requirement or, if so, we have not seen the data.

B The monitoring system only records time-averaged exposure despite the fact some studies indicate peak levels are often of more concern.

C The monitoring system for PGV is inadequate to determine exposures to those proximate to the plant. In actual incidents, measured exposures reported by PGV and/or DOH are claimed to have miss or underestimated exposures to the community by over a factor of ten. This is apparently primarily the consequence of the placement of monitors.

D No modeling system is commonly used to determine exposure gradients for known releases. Moreover, the difference between theoretical and experienced exposures is confounded by weather and topography.

Even with the prospect of improved monitoring, the Study Group has been compelled to think in precautionary terms based on reasonable worst-case scenarios, any of which could be repeated in the future.

2 H2S Exposures and Health Harms

The State of Hawai‘i has set H2S standard limits for PGV at 25 ppb in a 1-hour period as read on the three stations on the perimeter of PGV and at one DOH monitor. These limits correspond to the legal maximum allowed to the general population. Based on what is known about HGP-A, the Study Group reasons that past peak exposures to communities within one-mile of HGP-A almost certainly have ranged well above 5,000 ppb at some one- to five-minute intervals. These estimates are based on data, assumptions, and calculations. With measured exposures reaching an hourly average of 4,296 ppb in 1982, it is assumed that exposures at peak were greater than hourly averages and that monitoring was not optimally placed to capture the highest exposure data. Short-term exposures could have reached 50,000 ppb or higher.

Because (a) some researchers believe transient but very high exposure levels are equivalent to or exceed the detrimental effects of lower, but long duration levels and (b) up to this point, monitoring has been largely reported in hourly averages (as opposed to transient peak levels), it is desirable to estimate the difference between peak levels and 1-hour averages. Such an estimate will ultimately describe a factor between maximum expected peak values as a function of actual readings. The Study Group does not have sufficient data to develop an equation, but an approximation is possible using data from a recent episode at the PGV plant.

At upset condition at PGV on March 13, 2013 resulted in a response by HCCD. Monitors at the PGV plant measured an hourly average of 19 ppb. Beyond the plant’s boundaries, HCCD personnel, using a hand-held device with a minimum detection of 1,000 ppb, recorded short-time values of 1,000 ppb and 3,000 ppb. Dividing the instantaneous values by the hourly average measured at the monitors suggests that peak values could be approximately 100 times hourly averages. Many more observations using identical equipment, operators, calibration history, and vertical placements are required to refine and understand this factor, allowing its use as a conversion rather than simply a bounding estimation.

Assuming for illustration purposes that the factor of 100 is valid, this number can be used to determine an upper limit of estimated unmeasured peak values from monitored hourly averages. On August 25, 2005 an hourly reading of 789 ppb was recorded during well clean out with an evolution of events that seems to have propelled the plume upward in a similar fashion as on March 13, 2013. Applying the factor of 100 developed above, exposures may have reached 78,900 ppb for seconds or minutes. Although exposure as a function of distance will go down, Goddard & Goddard’s observations during the June 1991 blowout state that the plume of gas and aerosols ranged over 10 miles.

3 H2S Health Effects

The science of H2S is still evolving, especially at chronically low levels of exposure that may be accumulated. There is some evidence that CNS and respiratory effects may be two of the primary impacts of H2S exposures at repeated high and/or low concentrations. SO2 in vog is not unusual in Puna and it could affect some subpopulations when it does occur. Some studies also suggest that CNS health effects caused by peak H2S exposures are cumulative and may not diminish with time without medical intervention. Research is unclear as to whether both low-level and/or continuing exposures or short-duration-lower or medium exposures (less than 1000 ppb) to H2S may correlate with adverse health effects.

Taking a conservative and precautionary view, this suggests that those exposed to H2S fugitive emissions may be at increased risk of incurring negative health effects caused by geothermal development.

4 Health Effects from Other Geothermal Emissions

While H2S has occupied most of the Study Group's attention, the possibility of other negative health impacts has been raised in conjunction with geothermal energy development operations both at HGP-A and at PGV. Sodium hydroxide, known as caustic soda or lye, is known to react with some heavy metals to form precipitates. Heavy metals can be entrained when geothermal fluids are released to the atmosphere. Heavy metals and other contaminants are contained both in the geothermal fluids brought up, in the scale that accumulates on well walls that must periodically be cleaned, and in the fluids that are injected.

5 Noise and cultural stress related to geothermal development

Long-term exposure to noise, in particular certain frequencies of noise, has been shown to affect mental states and create anxiety. Some researchers now assert that long-term exposure to continuous vibration can negatively affect physiological and psychological conditions in some people. Long-term stress has similar effects. Worries about impending problems can lead to a variety of Anxiety disorders and possibly to other physical disorders. Cultural stress may also be a factor.

6 Recommended health study

The Study Group recommends that a formal, scientifically robust study of H2S effects be conducted as follows:

- The DOH and other regulatory agencies should require all geothermal plants to calculate the mass of fugitive emissions for any upset condition. These data are crucial to developing exposure data and for modeling of releases.

- A priority should be placed on examining (1) CNS impacts, (2) respiratory impact, (3) sampling for heavy metals and (4) monitoring for anxiety disorders.

- For people examined, the study should include a profile of estimated exposures using measurements, modeling, and estimates of peak exposures. This should be done for both H2S during incidents and for SO2.

- Exposure estimates should include short-term (seconds to minutes) peak levels and long-term levels in principal downwind communities (e.g., Leilani Estates, Lanipuna Gardens, Opihikao, Nanawale, and Kalapana Seaview Estates).

- The study should consider for control and comparison purposes (1) a community that is not likely affected by geothermal emissions (e.g., Kona or Kaʻū) but that is affected by volcanic emissions and (2) a community that is not affected by either geothermal or vog emissions. (e.g., North Kohala, Kauaʻi, or a possible mainland location). Estimates of exposures for all recommended chemicals are required at all communities and study sites.

- Once identified, the comparison and study communities should be compared, taking care to identify possible confounding variables such as pollens, molds, smoke from other sources, and differences in comparison group demographics.

- The health effects study should examine the effects on subpopulations that may be more sensitive to the effects of H2S, other fugitive emissions, and noise and vibration (in utero babies, infants, Native Hawaiians, older individuals suffering from COPD, etc.).

- The study should determine, using body samples where possible, whether there has been exposure of residents to fugitive emissions that are released as part of geothermal operations.

- The study should systematically identify anxiety disorders that may be associated with cultural stress, noise and vibration, living near geothermal project development, having directly experienced geothermal gas releases and/or having been evacuated, having experienced the highest noise levels, or having association with other geothermal stressors.

- Although the study will primarily focus on H2S, to the greatest extent possible the study should consider possible interactions between H2S and other geothermal emissions and other chemicals.

- The study should adopt a multidisciplinary approach, putting those evaluating medical effects in close teamwork with those measuring/estimating exposure and those working on statistical issues. As described later, a study design emphasizing this teamwork should be an evaluation criterion for all proposals.

- The recommendation to study a set of spatially separated areas may make this study significantly more complex than previous studies, which considered only one area alone with one comparison. Consequently, the health effects study should use the best statistical analyses available. This should be an evaluation criterion for each proposal. In addition to standard CNS and respiratory measurements, the study should incorporate detailed medical histories and appropriate blood chemistries (e.g., cortisol could be used as markers for stress levels if appropriate.)

- Determining anxiety disorders from cultural stress will likely require a methodology different than geographic comparison of groups. Additionally the study will likely require a researcher on the study team who must be an expert in understanding and studying health issues in indigenous populations.

2 Conduct a review & meta-analysis of H2S health effects

The Study Group believes the literature of H2S health effects related to low-level, long-term geothermal development has not been adequately reviewed. In addition to traditional literature reviews, one of the best methods to accomplish a robust review is a "meta-analysis" of all relevant information on the H2S topics covered by this report. We recommend that a literature review and MA be performed on the Study Group's topic of primary health concern: the effects of geothermal-derived H2S on CNS and respiratory function.

Discussion

The Study Group has examined and reviewed a wide variety of information ranging from peer-reviewed publications to internal data supplied by PGV and others. This examination has been selective, in places cursory, and has often required more time and expertise for analysis than was available. Assuming it can be done expeditiously, a literature review and MA, or "study of studies," is recommended.

Meta-analysis is the statistical analysis of previously performed studies in which quantitative estimates of the magnitude of a response to a treatment are measured and in which variability within samples is documented. MA was originally applied to fields in which controlled experiments were performed (e.g., clinical trials of drug efficacy), but MA can be and has been widely applied to non-experimental studies. A brief historical review can be found at: http://en.wikipedia.org/wiki/Meta-analysis. An organization devoted to the medical applications of MA is the "Cochrane Collaboration" (www.cochrane.org).

In MA, the basic quantity taken from previous studies is the "effect size" divided by the sample variance, where "effect size" is typically measured as the difference between the treatment and a control. For example, if reaction time is measured on a control sample (say, "RTC") and a sample exposed to H2S (say, "RTS"), then the MA study effect is "(RTS-RTC)/Variance." When calculated for all the reviewed studies, the average study effect and its variance can be computed. Further analysis can provide evidence as to the overall magnitude of the treatment based on the average study effect.

Two challenges of a successful MA are accounting for bias (e.g., publication bias due to the fact that results of "no effect" tend not to be published) and inadequate sample size (e.g., too few of the studies report the necessary information).

We recommend that an RFP be advertised and funded for a wide ranging literature review and associated MA on geothermal-derived low-level, long-term effects of H2S. The RFP should be separate from other RFPs, although the reviewing scientists may, but need not automatically, be different from the health study team with the provision that a competent biostatistician must be a member of the review team.

The Study Group is clear that the completion of the MA should not delay the initiation and completion of the health study recommended above. At the same time, the Study Group believes that for the MA to usefully inform the results and conclusions of the health study, the MA should be performed independent of, or in parallel with the health study. If an aggressive schedule is maintained, the Study Group believes the MA study will not delay the health study and will be available to health study researchers and to subsequent policy considerations.

3 Establish a better monitoring system

Current monitoring systems and protocols are inadequate and must be substantially improved. Because responsibility for the monitoring and reporting of exposures is decentralized across different agencies and organizations, an effective

communication protocol, especially in the event of an emergency, is also essential. The County of Hawai‘i is the layer of government closest to the day-to-day lives of its citizens, and the health and welfare of its citizens must take precedence over geothermal interests. County of Hawai‘i needs to ensure that reliable gas, particle, meteorological, and noise data are readily available to its citizens in near real time, so that residents can make informed decisions to protect themselves from fugitive emissions.

Discussion

Understanding the exposure levels to fugitive geothermal emissions present in air, water, and soil is critical to understanding potential long-term health and environmental effects caused by geothermal energy operations.

Furthermore, under upset conditions, experience in Hawai‘i and elsewhere has shown that even a binary geothermal plant with normally low or even zero emissions, can rapidly change character for the worse. Under these circumstances, real-time geothermal plant perimeter and community monitoring of sound levels, wind speed and direction, and particularly of airborne hazards including H2S and particles, provides crucial data for emergency responders. But citizens in affected communities are often their own “first responders” and therefore need continuous access to up-to-the-minute hazards information. Disaster experts globally are strategizing ways to build stronger community “resilience.”

In spite of this clear need for continuous real time, gas, particle meteorological, and sound level data, monitoring to date has been inadequate either to protect affected populations or to inform health studies. These circumstances must be aggressively improved.

The components required to improve the monitoring system include:

- A resident monitoring expert(s) with masters-or-higher-level education and training in gas, meteorological, and water chemistry monitoring combined with a strong background in micro-to-meso scale gas dispersion modeling
- A change in the regulatory framework for geothermal energy development to require PGV to estimate the mass of fugitive emissions during an upset
- An improved real-time continuous gas, particle, meteorological, and ambient noise measurement network capable of furnishing data that will accurately define both the long-term low-level H2S exposures that may be associated with

normal plant operation, as well as short-term high-level gas and particle concentrations that have historically been associated with geothermal plant upset conditions

- For at least a subset of the continuous monitoring sites, stations should also include real-time SO2 gas monitoring in order to assess the effects of Kilauea's on going eruptions on community air quality. Elevated H2S will be tied principally to geothermal emissions, whereas SO2 can be expected to be released only from eruptive volcanic sources

- A publicly accessible information web portal that will provide quantitative, up-to-the-minute, gas, particle, noise, and wind conditions

More specifically, the Study Group recommends:

1 Resident monitoring expertise

Retain a fully credentialed and currently certified monitoring expert to help design and implement the new monitoring system and real-time monitoring information web portal. The monitoring expert should synthesize data produced by the newly implemented gas, particle, and meteorological measurement network, with state-of-the-art wind field and gas dispersion models. Through the information portal and public outreach, he or she should design a system that communicates the improved exposure estimates and their practical meanings to nearby communities.

The monitoring expert should be a designer, a steward of high quality data, and an air quality outreach coordinator. This expert should also work closely with the health study's Principal Investigator to ensure that air, water chemistry, and noise level exposure data is qualitatively and quantitatively sufficient to inform future health studies assessments. Finally, the monitoring expert should make recommendations about how County, State, federal and public stakeholders can effectively communicate and coordinate their efforts to achieve the program specifications below. The panel recognizes that it will likely be challenging to find a single scientist or engineer who has all these qualifications. In the case that a single qualified candidate can't be found, we suggest that the need be met by multiple individuals working together as a monitoring team.

2 New monitoring

It is important to expand existing monitoring efforts and ensure a more extensive, intensive, and rigorous monitoring program operated independently of geothermal developers or other entities with potential conflicts of interest.

Monitoring stations should be placed more carefully and strategically throughout surrounding residential areas, including low-lying and stagnant areas where emissions might be more prone to collect.

- Continuous real-time monitoring of H2S in the 0-10,000 ppb range, and SO2 in the 0-5,000 ppb range, each with an effective resolution of 1 ppb should be used along with 0-2.5 micron mean diameter inhalable particle monitoring with an effective resolution of +- 5 micrograms per cubic meter to record at 1 minute intervals to ensure that peak exposures in the range likely to affect human health are captured. In conjunction with the gas monitoring, meteorological parameters including wind speed, wind direction, relative humidity, rainfall, ambient temperature, and barometric pressure should be recorded on the same time base. These stations and their instrumentation should be internet accessible by the monitoring expert and maintenance personnel. Air sampling intakes for gas and particulates should be optimized both to EPA regulations and also at breathing zone level for humans, (five feet above ground level). All gas, particle, and meteorological monitoring and sampling equipment must undergo rigorous and routine Quality Assurance and Quality Control protocols to ensure that the data are of sufficient quality to inform health studies as well as protect public health. Real time data must be accessible to the public from the central, community-based monitoring information website (see 4 below).

    - Continuous sound levels and other vibrational energy measurements should be undertaken in order to quantify when excessive noise is being emitted by geothermal development. As with the gas and particles, the noise monitoring measurements must be Quality Assurance and Quality Control-checked and the proper archiving of all monitoring data must be assessable to the public at a central point.

    - Ongoing volcanic activity, especially gas emissions and seismicity, that is currently monitored by USGS-Hawaiian Volcano Observatory and that might affect residents close to geothermal development should be considered in both the planned health study and into the real-time monitoring activities recommended above.

All fixed continuous monitoring stations should be equipped with backup power systems that ensure continuous operation in the event of power grid disruptions.

3 Further considerations regarding station configuration

- While the monitoring review and design expert should come to his or her own determinations, the Study Group suggests the following be considered: The effects of geothermal emissions on east Hawaii communities are directly related to wind and weather. In keeping with the 1991 Goddard & Goddard Engineering study recommendations, the County should use its influence with state and federal agencies to acquire and sustain an understanding of the meteorological conditions of the area surrounding PGV and the adjacent residential communities. This may require that several taller (40 meter) towers be installed throughout a full 360-degree circular arc, centered on KS-15 in order to measure wind speed, wind direction, temperature, and humidity at 40, 20, and 10 meters. As with the other community gas, sound, and particle monitoring, up-to-the minute data from these battery/generator-backed-up stations should be transmitted to the central web facility and accessible by the community members in real time.

- Consider placing 10-meter meteorological monitoring stations in the following locations, pending review by the monitoring expert: Pāhoa; Kalapana Seaview Estates; and Kumukahi Lighthouse. Additionally establish a 40-meter meteorological and on the grounds of PGV near their gas scrubber. In addition to wind parameters, and to the health benefit of downwind communities, consider monitoring H2S at this site at 40, 20, and 10 meters. Real time data from this site could serve to augment community alerts in case of emergency upset conditions.

A primary goal of the new monitoring and sampling recommendations should be to provide a better understanding as to the precise exposure of communities to harmful gases, particulates, and sounds caused by geothermal development, as well as the effects of this development on water catchments and groundwater quality.

4 Community-based monitoring data and information

To address the historical shortcomings of timely monitoring information collection and dissemination, it is critical that the data collected by the continuous monitoring stations be available in near real time so residents and visitors have the information they need to protect their health and safety.

- Up-to-the-minute H2S, SO2, particle, noise, and meteorological data should be available in interactive map format on a single, central website. See for example: http://emdweb.doh.hawaii.gov/air-quality/

- The central monitoring information website further needs to provide interpretation of the current conditions, color coded as to current safety levels, along with reference to Frequently Asked Questions (FAQs) explaining these interpreted updates. See for example: http://www.hawaiiso2network.com/

- Especially for individuals who do not have Internet access, an interpreted monitoring information announcement, updated daily or more frequently when emergencies occur, should be recorded and posted on a local phone message site that is ADA compliant.

- Visitors to the central website should have the option to immediately graph and review or download archived historical monitoring data for at least the previous year in order to better understand the current hazard levels. For example, the National Park Service operates a download website for their parks that monitor air quality at http://12.45.109.6/data.aspx

- To address special needs and circumstances, portable, ppb-level H2S monitors should be available for community members to borrow on a short-term basis.

Under supervision of the monitoring expert, public outreach information materials that describe potential hazards and effects of ongoing geothermal development should be readily available to local residents and visitors.

4 Evaluate geothermal effects on drinking water & near-ocean environment

Geothermal energy production involves drilling through various geological layers, creating a possible risk of water contamination downstream of the reinjection site. As a separate initiative, the County should commission USGS to study the consequence of brine re-injection. Ocean contamination and possible near-shore die off should also be studied. Using robust scientific methodologies, the County should test the following hypotheses:

1 Brine that is deeply re-injected into the lower East Rift geothermal zone could be migrating vertically into near-surface water flows, causing contamination of the aquifers and the ocean shore brackish basal ground waters.

2 Contamination of the ocean shore waters caused by geothermal development could be affecting coastal and near-shore plant and animal life. (Pentane, along with other chemicals which should not be present or certain injectate

components, could serve as markers for injection fluid migration.)

Discussion

While H2S has occupied most of the Study Group's attention, the possibility of other negative health impacts has been raised in conjunction with geothermal energy development operations both at HGP-A and at PGV. Among these are lasting effects of the elements re-injected by PGV and possible residual pollution from HGP-A.

Injection wells increase pressure in the geothermal reservoir, and it is not always clear where re-injected water may migrate. Geothermal heating can lower the density of the saline water and induce localized upwelling of saline water into the fresh-water lens. In a 1994 study, USGS recommended further sampling and study to determine where injection fluid goes. The aquifer in Lower Puna, at least on the southeastern, "makai" or downstream side of the rift, is in general not fresh. It is warm, somewhat saline, and doesn't meet the standards for county drinking water, which is why several exploratory wells (e.g., Malama Ki) were never developed for potable water. On the Pāhoa "mauka" or upstream side of the rift, water quality is quite good.

Underground disturbances can occur naturally or can be caused or exacerbated by geothermal development. Additionally, contaminates entrained in higher flow rate water can settle out as the rate diminishes on reaching the ocean, leading to possible contamination near the shore. In some cases trace amounts of organic Rankine cycle fluids (e.g., isobutane) have been used as a marker to determine where injection fluids migrate.

The Study Group recommends that the County have USGS undertake a follow-on study to the 1994 study, "Potential effects of the Hawai'i Geothermal Project on Ground-Water Resources on the Island of Hawai'i." This follow-up study should be expanded to include effects of possible pollution in the ocean areas that receive the runoff from the Lower Puna area.

5 Assure credibility, reliability, & independence of health study experts

The Study Group recommends a three-group process. The first group is an independent group of professionals that administer the RFP, evaluate proposals, and submit a ranking of the proposals with comments justifying that rank. The second group is a cross-section of the community proximate to where a geothermal

plant is proposed. The final group is the County personnel that handle the legal and financial issues involved in setting up a contract.

Discussion

This recommendation addresses the development of the contents of RFPs and the process by which the RFPs are widely advertised to potential applicants and how they are evaluated and awarded. The central principles are transparency, simplicity, and balance. The procedure includes (1) RFP review and ranking by professionals unaffiliated with geothermal development and (2) RFP ranking recommendation by a committee chosen to represent citizens living proximate to the PGV plant as well as those residing in more distant regions of Puna.

1 Choosing the Three Groups

The Mayor will nominate at least three people to be part of the group of professionals (the Blue Ribbon Panel or the Panel) and nine people to the group that represents a cross-section of the community (the Community Committee). The County Council will approve or disapprove these nominations as a slate.

Nominees for the Panel should be drawn from the John Burns School of medicine at UH. Nominees, including three or more experts in health studies, biostatistics, and the measurement of airborne contaminants and sound/vibrations, need to be nationally recognized and have had success in obtaining, reviewing, and managing national-level research grants.

It is expected that the Panel will donate their time as a matter of professional courtesy. The Panel members will document that they have no conflict of interest with the nature of the RFP (i.e., have no involvement with geothermal energy development). We recommend that the County approach the John Burns School of Medicine at the earliest possible time to enlist their cooperation, in principle, in this endeavor.

Those nominated to the Community Committee should represent a cross section of the community, be community leaders, and be well informed on the issues. It is expected that they will donate their time. They should also live proximate to the geothermal development.

2 Developing the RFP

The disparate nature of health issues associated with geothermal development in

Puna requires distinct RFP criteria as described in other recommendations. The RFP should be written by the County with specific language that addresses the substantive hypotheses and methodologies recommended by the Study Group. The County Council shall approve or disapprove the RFP without modification.

The County should create and sponsor a web page to publicize relevant documents and to facilitate public input. The content of the RFPs will vary according to the subject (e.g., H2S, water contamination, etc.).

For example, the basic content of an RFP to study H2S health effects should be:

A. The RFP should specify that successful proposals will comprise a team of 3 researchers who are expert in health studies and epidemiology; monitoring airborne contaminants and sound/vibrations; and biostatistics. Other disciplines may be necessary at the discretion of the successful proposer.

B. The RFP should establish research team qualifications and a proposal structure. In addition to content listed below, the proposal must contain professional curriculum vitae of the team members as follows.

   - The health discipline team member will document peer-reviewed publications in their discipline. Publications that deal explicitly with H2S, sound or vibration effects, and other health effects as discussed in other recommendations will be preferred.
   - The monitoring specialist must be licensed and certified as noted in Recommendation-3 and show publications or reports in appropriate technical outlets or final technical reports for contract work that required monitoring those substances and phenomena identified in the RFP.
   - The biostatistician team member must show peer-reviewed publications in biomedical statistics or general biostatistics, or publications dealing with statistical methods appearing in peer-reviewed discipline journals with a strong emphasis on quantitative approaches.

   Each team member must disclose all financial gain received by past H2S and geothermal studies, as well as past involvement in litigation and in pro- or anti-geothermal advocacy.

C. The content of the RFP may specify the nature of the health assessment to be performed, the statistical issues that must be resolved by a successful proposal, and the monitoring and exposure data to be collected. These specifications should include the recommendations included in this Study Group report. A copy of this report as well as the RFP should be posted to a County web page.

D. In order to compare proposals, the RFP should clearly state the desired structure of the proposals. A possible structure might be:

- Literature review and hypotheses to be tested; procedures to identify affected communities; sample randomization procedures
- Health assessment tests to be performed; other health and medical data to be collected; procedures for maintaining databases and insuring data privacy
- Monitoring details: types of monitors; placement of monitors; calibration of monitors; presentation of monitoring data for public access
- Statistical tests
- Budget
- Curriculum Vitae of investigators

3 Review and Evaluation of Proposals

Procedurally, the Panel will have the following responsibilities:

A Publicize and disseminate the RFP nationally

B Directly receive the proposals and identify a set of at least 5 outside reviewers taken from research institutes, universities, federal laboratories such as the CDC and other organizations. Anticipating a modest number of proposals, it is highly desirable that all reviewers read all proposals. If this is not possible, the Panel will assign proposals to reviewers according to criteria of their choice.

C Insure confidentiality of reviewers. This requirement is necessary to ensure objective reviews and to maximize the pool of potential reviewers; anonymity is the standard procedure for national reviews.

D The Panel will examine the proposal reviews, rank the proposals according to a method of their choice, and write an assessment of the proposals with their recommendations to the Community Committee. This assessment, with reviewer anonymity protected, should post on the County health study web page.

4 Community Review

After it finishes its work, the Community Committee will be provided the ranking and justifications from the Panel. If the Community Committee desires, it can also

be provided copies of the proposals from the various applicants. The Community Committee will recommend changes, if any, to the Panel's ranking and provide the modified ranking, along with written justification for the change, to the County. This will be posted to the County health study web page.

5 Final Proposal Selection

The next step is to select a contractor. After the Panel and the Community Committee submit their rankings and justifications, the Mayor will, after a noticed public hearing, choose the proposal to be funded. A report of the Mayor's selection should be posted on the County web page dedicated to the health assessment RFPs.

6 Ensure there is no old or ongoing contamination from HGP-A

The Study Group recommends the County use the full strength of its influence with State and federal agencies and private landowners to ensure the old HGP-A site is free of contaminants. Soils and water channels in the area of the five old HGP-A brine pits should be studied with vertical samples deep enough to go beyond the fill used to cover old pits. Any survey should examine whether and to what extent contamination occurred and what re-mediations, if any, may be required.

Discussion

During its deliberations, the Study Group toured PGV and viewed the perimeter of the old HGP-A project. HGP-A was also the source of some discussion in regard to possible legacy contaminations from H2S and metals. The Study Group understands PGV was investigated as a possible Superfund site but was, after investigation, not designated. However, the group believes HGP-A may have emitted as much as 4,900 pounds of lead, 520 pounds of chromium, 2.9 pounds of arsenic, and 0.36 pounds of mercury per month unabated. Uncontained, as the brine pits of HGP-A were, elements emitted may have entered ground waters. It is not clear that the sampling penetrated the infill of these pits.

While it may not be the County's ultimate legal responsibility, the County can use its influence with State and private landowners and federal agencies to ensure the site is contaminant free. Soils in the area of the five HGP-A brine pits should be sampled extensively, especially in the vertical direction. Samples should be deep enough to go beyond the fill that has been used to cover the pits. Any survey should examine whether and to what extent contamination occurred and what

remediation, if any, may be required to avoid their spread if contamination did occur or currently exists.

7 Strengthen Public Communications & Alerts

Since geothermal energy production involves health and safety risks, announcements, messages, and emergency declarations must reach the public in a timely manner, especially those in close proximity to geothermal operations. The more severe the condition, the more urgent the communication required. We urge the County to install and update its notification procedures and consider a variety of mechanisms to provide alerts to the public when upset conditions occur.

Discussion

In conjunction with the upset conditions reported by PGV, the Study Group heard numerous complaints about incident alerts. A recurrent complaint was the long delay time between the occurrence of an upset and PGV's formal notification to relevant agencies. Because such delays could put geothermal neighbors at risk, a more responsive protocol for timely communication of upset conditions seems imperative. The Study Group recommends the following:

1 Automatic Alerts

In addition to the procedures PGV currently has in place, a computer program should be installed at the plant that would be triggered automatically and by plant and HCCD personnel during an upset condition. This would simultaneously and automatically alert emergency responders, a pre-established and pre-subscribed community phone list, and an on-site siren. This should be required of and paid for by PGV. Hawai'i County Civil Defense should launch a resident notification program that not only sends emails but that also delivers a recorded phone message to persons who have subscribed to receive alerts. For example, Puna Pono Alliance reports that it has 870 members currently subscribed, in place, and available for notification. Other community and neighborhood associations may also have lists. These organizations should work with the County to expand subscriptions to include all residents within at least a three-mile radius of any geothermal power plant.

2 Community Education

A media education program on how to sign up for notifications and what to do in case there is an accident should be implemented. It should include a list of who to call in case of accidents with a map of escape routes to safely leave the area in case

of H2S or other dangers. HCCD should make every effort to identify members of sensitive sub-populations for special notification.

3 Sirens

PGV should also install a siren at the plant. The tower on which the siren sits should have a 360° rotating camera that automatically activates during upset conditions. The siren at PGV should be programmed to trigger when there are emissions above 25 ppb lasting more than one minute on any monitor.

4 Interim Measures

Until such time as HCCD can ensure that the PGV plant siren is fully operative with the capability of being operated independent of other countywide sirens, notification of residents should use all available methods and media, including automatic text and internet alerts, sirens on patrolling vehicles and bullhorns. TV and radio PSAs. "This is your Hawai'i County Civil Defense…" should be part of the permanent notification system.

5 Department of Health

The County should use its influence to ensure that DOH fills the currently vacant position of East Hawai'i Field Investigator. This employee should automatically be the recipient of alerts or notifications of upset conditions. The task of immediately responding to geothermal upsets should be included in his or her job description. The DOH should also have an easy-to-find and easy-to-use 24/7 response line for geothermal complaints and reports and record all complaints. These records should be available online for review by all agencies, regulators, and the public.

6 Other County Agencies

When upset conditions occur, the County Planning Department should send their own Field Investigator to the site with the same duties as above. Further, Hawai'i County Police and Fire Departments should respond as needed and keep detailed records of these events.

7 Community Response Partners

We recommend a community partnership program be established to help with notifications, alerts, and other communications. Similar to a neighborhood watch, this program would work in concert with the County (HCCD, HPD, Department of Planning, DOH, and others) on a volunteer basis to help ensure community

emergency response team. The partnership could have a quasi-regulatory function adapted from and modeled after Lake County, California.

8 System Tests

A test of all emergency response and notification systems should be held annually.

9 Drills, Evaluation, and Lessons Learned

Periodically the County should exercise the key elements of the emergency response plan, using credible PGV accidents as the driving scenario. These exercises and real world responses should be formally evaluated to extract lessons learned for improvement of the emergency response plan and the capabilities of those that respond.

8 The County should commission future geothermal developers to fund & conduct water resource & health baseline studies prior to drilling & development

Geothermal development can affect the health and well being of people surrounding the plant during dramatic accidents like the KS-8 blowout in1991 and potentially during smaller upsets and operational releases such as occurred in 1997 and 2005. By establishing a baseline health study that measures the same parameters explored in Recommendation 1, future health studies can more easily establish the magnitude and responsibility of health effects.

Further, geothermal development may affect water wells downstream from the development area as well as the coastal basal brackish groundwater and the ocean near the geothermal plant. By establishing a baseline using the methodology of the study of Recommendation 4, future water studies will be able to establish more easily the magnitude and possible responsibility for environmental impact from geothermal development. If possible, USGS should conduct this study.

Discussion

1 Baseline Health Studies

Before geothermal development begins, a geothermal developer should fund a county-approved independent, baseline health study to establish a basis for any comparison of emerging effects of future geothermal development and production. The target area of study should include local surrounding communities that could

be affected by exposures to peak concentrations of 25 ppb or more in worst-case accident scenarios.

By doing baseline studies, the power of statistical analysis is much improved. Comparisons can then be made to geographical areas affected or not affected as well as conditions before and after exposures. This allows for the magnitude and responsibility for any negative health effects to be determined.

The baseline health study could be fashioned after the health study is done to fulfill Recommendation-1. Regardless, it should establish community health demographics and a baseline for CNS health, incidence of respiratory dysfunction/disease, cancer, reproductive health matters, and other health issues. Ambient noise level, ground contamination levels, and air contamination baselines should be established throughout the community. Vulnerable sub-populations (e.g., the young, the old, and the infirm) should be identified.

It would be logical that the same research team that acts on Recommendation-1 could do the baseline studies.

2 Baseline Water Studies

In 1994, USGS conducted a study, "Potential Effects of the Hawaii Geothermal Project on Ground-Water Resources on the Island of Hawaii," by Michael L. Sorey and Elizabeth M. Colvard. This study recommended follow-on studies, noting the possibility of surface water contamination by geothermal development. To date no follow-on study has been done, but the 1994 study can serve as a partial baseline reference. Unfortunately the study was done after many years of geothermal development in Lower Puna and possible causes of water contamination during that period are now more difficult to sort out.

Future geothermal development should take advantage of this lesson learned. By conducting a study like the 1994 study, a baseline will be available to establish the magnitude and responsibility of possible environmental impacts of future development on water resources. This study would establish which aquifers could be affected, the thickness of the fresh water lens, and the chemical composition of brackish water resources. These values might then be used for benchmark comparisons at future dates. It should be noted the 1994 USGS study cautions that drilling in areas south of the rift zone and west of the rift zone could cause issues not faced by current PGV operations, making the need for such baseline studies even more important.

VI

Concluding Thoughts

Before finalizing this report, the Study Group published a working draft and invited members of the public to submit comments electronically to the project website and/or orally at a public meeting held at the Pāhoa Community Center on August 15, 2013. Approximately 40 people provided written comments and 34 people presented 3-minute testimonies on August 15th, some of them more than once. All comments received in all forms have been collated and are attached at Annex-2. Readers of this report are urged to review them in detail to better understand some of the issues of concern to some of the people in Puna.

The comments received and heard by the Study Group led to valuable additional deliberations, a number of factual corrections, and substantive and stylistic improvements. Some of the themes brought forward by members of the public in Puna are beyond the scope of this report but may prove valuable for Mayor Kenoi, members of the Hawai‘i County Council, the Windward Planning Commission, and others involved in geothermal energy production.

The Regulatory Problem

Geothermal energy development and production is overseen by a variety of agencies. Most of these agencies are without sufficient resources and wherewithal to enforce proper oversight. The Study Group believes this array of competing jurisdictional purviews is a hodgepodge and does not serve the interests of the County, the State, or the public.

The State of Hawai‘i legislature and the Governor have preempted much of the County of Hawai‘i’s previous control over when, where, and how geothermal development might take place. Hawai‘i County Planning Department and HCCD play important roles in land use permitting and emergency response and manage several funds for relocation and other purposes. However, under current arrangements, BLNR/DLNR is responsible for overseeing most major land use

siting matters, drilling activities, and reservoir management. The State of Hawai‘i also collects royalties.

Another obvious regulatory shortfall, as previously noted by the County in PGV's GRP-2, is that noise at residences near the plant can be as high as 70 dBA, an industrial limit. The County has authority to establish regulations to fix this inequity.

EPA and DOH bear the greatest responsibility for the oversight of injection controls, the protection of drinking water, the maintenance of air quality, the monitoring of noise and H2S, and the oversight of any third-party monitoring assigned to others. DOH is also responsible for federal and state emergency response preparedness. EPA has delegated many of these functions to DOH. There is considerable cynicism amongst many members of the public regarding DOH's ability to manage their designated oversight responsibilities.

The public appears confused by this patchwork of federal, state, and local oversight. In effect, responsibility for general record keeping and the management of upset conditions is diffused across agencies. In some cases, oversight responsibilities appear to have been delegated to geothermal energy plant operators, which creates at least the appearance of a conflict of interest. Though the Study Group has not examined it in depth, one possible better model may be the Geysers Air Monitoring Program (GAMP) in Lake County, California. GAMP is a tripartite commission made up of representatives from government, industry, and community citizens which creates a forum for constructive engagement on air quality monitoring and oversight.

Native Hawaiian Health Issues

Native Hawaiians were not specifically represented on the Study Group though they were invited. During the public comment period on August 15th, several Native Hawaiians and non-Hawaiians faulted the Study Group for this and argued that the report is deficient because of this. The Study Group agrees and recognizes this deficiency.

Pele is arguably one of the most widely known deities in Hawaiian culture and, as the Study Group understands it, the subject of specific "Pele Practitioners" who assert kinship with her. These worshippers, as well as other Native Hawaiians, have inherited a rich tradition of Pele-centered legends, dances, chants, stories, ceremonies, prayers, protocols, and imagery.

Though the Native Hawaiian community, just like the public at large, holds diverse views on the development of geothermal energy, arguments were offered on August 15, 2013 that some Native Hawaiians may be suffering from unique

psychological, behavioral or emotional health problems as a result of geothermal energy development added on to other historical cultural insults. This causes suffering in ways that may be unique to Native Hawaiians and that the group did not study and that the Study Group is unable to document or substantiate. Some pertinent late-acquired documents and resource materials have been added at Annex-4 but there is more to be studied.

Dr. Kaye Kilburn

Many people in the Lower Puna community expressed their belief that Dr. Kilburn represents community interests. They also cite a measure passed by the County Council in 2012 but vetoed by the Mayor, and they urge the direct appointment of Dr. Kaye Kilburn whom they prefer.

The Study Group does not view the selection of specific researchers as part of its mandate and believes the County's procurement procedures would probably not allow this. However, the Study Group believes Dr. Kilburn is an eminent, respected scientist with a long history of work on H2S. Along with other interested, qualified scientists, he should be cordially invited to submit his credentials for consideration.

Further Geothermal Development

The Study group is fully aware proposals for additional increments of geothermal energy are in progress and bids are being received by HELCO. The group hopes the concerns and recommendations raised in this report will be given the fullest consideration in HELCO's review of proposals and the acceptance of any bidder.

On August 15th, a number of testifiers expressed their personal beliefs that any further geothermal energy development should be held in abeyance until the studies recommended in this report are completed. While the Study group takes no position on this except as noted in the recommendations, the group believes that past failures to undertake baseline health and environment studies has manifested in many of the difficulties encountered in trying to establish a sound inventory of jointly agreed facts about past and current exposures and impacts.

Geothermal energy production has existed in Puna for over three decades, first through HGP-A, then through PGV. Today, the public, most especially those living in proximity to PGV, do not really know to a high degree of confidence and certainty what has changed either with the health of local populations or with the environment. Unforeseen incidents of different magnitudes still occur and many neighbors of the PGV plant do not know, other than through episodic noise or reports or direct observations of upsets, how incidents may affect them.

Baseline references for air, soil, and water conditions, as well as ambient noise, will benefit everyone. The careful monitoring of exposures to help inform deviations from baseline norms should automatically be a part of permit conditions and in place before drilling commences. Additionally, if in fact the other testing recommended in this report points towards geothermal plant operations as a source of harms, new requirements to address those harms must be put in place before full operations commence.

In conclusion, the Study Group thanks Mayor Kenoi for his leadership in setting this effort in motion and urges the fullest consideration of the findings and recommendations.

VII Annexes

1 Individual Statements from Study Group Members

Jay Bondesen

Personal comments on the Study Group, the Process, and the Findings

On our first trip to Puna my wife and I were able to travel through the National Park and follow the coast through Kalapana on the red road. It was a wonderful day and even then we wondered what it would be like to live here. Fast forward twenty-five years and we were here looking for a place to build a home for ourselves. Then move ahead through another eight years. We have by now made many friends and found the extra time to get involved with the Leilani Community Association and various volunteer efforts in the district. This is our home and although change is inevitable we want to protect and maintain the core of what Puna represents.

Part of what brought us here was abundant fresh water, clean air, and the attractive lifestyle that can be found in this part of Hawaii. We were well aware of several potential negative issues with regards to living in Hawaii and specifically in Puna; Albezia trees, Miconia, Coqui frogs, minimal police and fire services, few choices for medical care, and noise from helicopters and the geothermal plant. Living in a tropical climate also poses some additional health risks not seen in our previous life where the annual rainfall is about 10% of what we get in Leilani.

Two years ago we started hearing more about possible negative health impacts caused by the geothermal plant. No one we knew had suffered any effects that could be attributed to living close to the plant but there was a group of people that were convinced it was in fact making them sick. It turned out that there were enough people that some on the Hawaii County Council decided that something must be done, and they proposed what they thought was a good response. Unfortunately they overstepped and the Mayor rightfully vetoed the proposal. The idea of condemning property just down the street from me was clearly not

necessary based on what I knew but rather was an emotional reaction to a perceived threat.

Along with anyone who has given it any thought at all, I am in complete support of determining if in fact the Puna Geothermal plant is having an adverse impact on either the environment or our health. I applaud the Mayor for taking this step in order to try and answer those questions before legislating controls. I think funding this effort with the specific goal of creating the roadmap to achieving answers is a good approach. Dr. Adler has been thorough in his efforts and the individuals participating have been able to work together in order to produce this document.

A problem arises in that for many this is a passionate topic and yet it requires a dispassionate review. There are many people, including some in this study group, that are convinced that the Puna Geothermal plant has caused, and continues to cause, serious health and environmental damage. There are also some who don't want any type of development in the district and others who don't like HELCO or the power grid. These people believe that they see a real problem, are suffering the consequences, and have dedicated themselves to educating the rest of the community. Regardless of their motives, these are serious concerns to them.

At the same time, many others in the community see the complaints, and the people making them, as a minor issue, some kind of a fringe group just looking out for themselves and ignoring what the mainstream members of the community have to say. They look askance at the way these people dress or talk and even at how they live their lives. They see no ill effects among their friends and attribute many of the complaints they hear about to lifestyle, hygiene, or poverty. This is not a unique situation, when two groups of people are suspicious of what motivates the other. Also probably not unique is that both groups overlap on at least one core concern; is our health being compromised? What we need to do is answer that question. Somehow the discussion has lost focus and we need to regain that. Everyone should accept the fact the answers are out there and we simply need to find them. Too many of us formed our opinions only hearing parts of the story and our goal here is to get the bigger story out.

We are recommending several things that just may arrive at some answers. Some, about monitoring and testing the environment are a given. More of that data would have made this process much simpler. Arriving at what current science can tell us about what to look for in both the environment and people, something that points to causation, would be a start. Some of our recommendations seem to presuppose a risk and may be an attempt to penalize the developer. It's difficult to argue against this when history shows that developers are not always the best neighbors. The

fear that some hold, feeling that there is a conspiracy of some sort has also made it difficult to let professionals move the process forward.

I am personally curious but not alarmed due to my proximity to the plant. I agree that mistakes have been made by the plant and every agency that was supposed to be regulating it. I think a change is overdue but we need more and current information to formulate the changes required. I believe in technology's ability to overcome obstacles and yet there seem to be regular incidents at the plant. The promise of less expensive electricity has not materialized and those impacted by living close to the plant can only see a downside to the arrangement.

I share a view held by many that burning fossil fuels is damaging the planet yet that is what we mostly use for baseline power. I feel sick when parked next to a diesel truck yet we have no State vehicle emission regulations. I know that agricultural use of herbicides and pesticides, including poison bait, is lightly regulated. I believe lead paint and solder can be found in the district. I really do think that we need to follow through with a health study on geothermal development. At the same time the well-being of our community is a much bigger topic and the challenge is in how to grow it safely.

Alfred Dettweiler

As a member of the community health study group and a close neighbor to Puna Geothermal Venture (2,700 feet away from PGV), this will be my thoughts and comments and suggestion.

After reading and listing to all the hundreds of documents I read with regards to both H2s and environmental studies, and testimony from both the community and health experts this was truly a learning experience. I want to thank Peter Adler and all the members of this Puna health study group for all the voluntary time they have spent on this project it truly was a huge undertaking.

I believe that after all the research, my concerns are still with the community with regard to health and safety issues. I now know more now about H2s and its health effects. I also know more about PGV and its operation. But my biggest concerns are about Civil Defense and police and fire response. This is the whole issue. The day to day operation of PGV does not concern me as much as the failure for the State and County to oversee and enforce the health and safety of lower Puna. It is quite clear that the state and county government were more concerned about developing Geothermal at all costs, including the residents living close to the PGV plant. Now that the cost of fuel oil is so costly the State and County and HELCO want to increase geothermal development at the cost of the members of our community again.

After living here in Leilani for 21 years and living with geothermal development, I believe that the H2s is the one of the biggest concerns. If all the other issues that needed to be addressed were, a large part of the H2s impacts would have been resolved.

1. Complete oversight of the Geothermal Development buy the Federal, State, and County. These agencies failed in their oversight, reporting, and keeping the community informed. There is no accountability from any agencies, this is totally unacceptable. When thing go bad, no agency or developer wants to take responsibility. Accountability is the key here.

2. Civil Defense - Most impotently must have a plan for all types of geothermal upsets. To date I have not seen a plan on any kind. Every time I had a conversation with CD they give me a general plan from their head but no official paperwork to support their plans.

But first and most important: All members of the community that live within 3500 ft. of the PGV plant must be informed about all incidents that may be of concern to this community. At one of the Puna group meeting the new civil director Darryl Oliveira informed the group that he planned to have the Leilani CD sirens upgraded and a different audio sound for a Geothermal incident. Darryl also mentioned that he planned to have an e-mail notification for all the residence concerned. The most appropriate way to handle this issue is to use a reverse 911 system. This system will then ring all of the community members in the affected area with a verbal notification. This action must be the highest priority as it will be the most effective and efficient way to contact a mass group of residences. I also believe that this system will work with Cell phone service that means you will also be able to route effected citizens away from the hazard area, and reroute an evacuation area. This would more effective then radio or TV. Also, this eliminates the total confusion that was caused when KS 8 well exploded back on June 12 of 1991.

I also suggest that Civil Defense have an annual meeting with all citizen of lower Puna. This annual meeting may include new updates in the emergency response plan, how to be prepared and respond to a possible H2s leak. Also, other safety issues such as Earthquakes, Hurricanes. What items need to be included in emergency kit such as water for all family members for 3 days, canned goods, dried food, etc. This practice should have been in place for years but has never been implemented. CD needs a complete rework in these areas. Leilani has a Community Emergency Response Team (CERT). The CERT team has visited the PGV plant and was informed about the risks of H2s. In the event of a PGV incident the cert team will not be required to respond. The CERT team may open the Association Office for temporary evacuation for residence living close to the plant.

3. Evacuation - The exciting 3500 ft buffer zone is sufficient. I don't see the need to make the evacuation zone bigger. Living in the 3500 zone I don't see any life threatening issues however. That does not mean that there is not a health issue. Living in this area we have had numerous H2s incidences. Noise and H2s have always been the biggest concerns for us living here. These two concerns could and should be addressed. I believe that the Puna health study group recommendation covers this area.

The main reason that we no longer wish to live so close is the stress and the lack of information from the Health dept. Poor or none State or County monitoring adds to the stress levels. At our age we no longer are willing to deal with these issues. As far as the Leilani sub-division is concerned the lower portion of Leilani from Hookupu St., East to Pohoiki Road and north of Leilani Ave. should be considered

an Evacuation zone and must be disclosed in "all" Real-estate transactions. This includes private sales not being sold by a real-estate broker. The Planning Dept., Building Dept. and Health Dept. should have a record of all the properties in the evacuation zone and there TMK's. There are still many lots in this area that are being sold without full disclosure. This is totally unacceptable. It should also be the responsibility of the Leilani Community Association to inform any all new member of the association that there is Geothermal Development close to the subdivision. In there welcoming letter explain that there maybe some people sensitive to low levels of H2s. but this is not a common event.

As a member of the Puna Health Study Group and past President of Leilani Estate Community Association I can say that in the early years of Geothermal development there were some serious health impacts to community members living within the 3500 ft of the development. However in the past few years there has been less impact from P.G.V. due to new improvements in their internal monitoring.

In 1996 Puna Malama Pono an activist and health group was awarded a $20,000 grant from the E.P.A. for $1,600 for a Jerome 251 monitor capable of reading down to .001ppm.the balance of the grant was for a laptop computer, noise monitor and GPS locater. The plan was to record and confirm H2s leaks and where they were located and time of day. The H2s data was recorded with a data logger located in the rear of the Jerome and set to record every 3 minutes with time date stamp.

At the beginning we had about 10 volunteers and they had a schedule to maintain. After about 6 months there was lack of interest and we were left with one person to monitor. At that time the Jerome was located at my residence on Kupili St. just 2500 feet from PGV. The Jerome was located on my Lani that faces the PGV plant. In the event that a community member complained about smelling H2s or other odors that may be hazardous I then calibrated the monitor and responded to the complaint. For the most part I rarely saw a reading above .010 ppm. In Leilani there was a background H2s level of about .003 24/7. This however dropped to 0 about 2007.

I don't believe that adding additional geothermal development is a sound idea. All the impacts that the community suffered in the past may be doubled or maybe worse. Adding more Geothermal in this community should have never been allowed without the proper monitoring as suggested by GEOTHERMAL PUBLIC HEALTH ASSESSMENT STUDY GROUP.

James Haefner

How to Write a Successful Proposal (or RFP) for a Geothermal Health Study in Hawaii

Advice for those applying for the H2S health study RFP and for the RFP creators.

Assuming the RFP to perform a study of H2S health effects follows closely the recommendations contained in the Final Report, below are some issues to consider in a high quality proposal. Applicants must recognize that the hypothesis that geothermal development in Hawaii causes negative health effects is politically contentious and socially divisive. As a result, if the Report recommendations are followed, typical scientific procedures for evaluating and awarding proposals will *not* be followed. The ultimate decision of the successful proposal will be influenced greatly by a panel composed of private citizens and members of the current County government. Few of this *Community Committee* will be trained scientists; fewer still will have expertise in toxicology, epidemiology, or statistics. As a result, the successful proposal must provide background and explanations that are not usually provided in proposals to national scientific review boards (e.g., NIH, NSF, USGS).

1. **Personnel**: Create a unified, coordinated team comprising experts in health analysis, monitoring, and biostatistics. Describe the biostatistician's tasks to emphasize design activities early in the project and analysis details at the end of the project. It is not appropriate that statistical design and analysis be relegated to a secondary role and employed only after the study is complete. The proposal should describe close communication between the monitoring activities and the health study, so that statistical analysis can evaluate the degree that the PGV geothermal plant causes negative health effects. Atmospheric dispersion and digital elevation landscape modeling expertise on the team will permit integrating health effects with current H2S exposures. In addition to researcher résumés as described in Report Recommendation 5, emphasize past collaborative projects the team has performed that integrate monitoring and health effects. Each team member must disclose all financial gain (grants, contracts, salaries) received by past H2S and geothermal studies, as well as past involvement in litigation and in pro- or anti-geothermal advocacy.
2. **Statistics**: The Final Report recommends a health study more complicated than previous studies evaluating H2S effects: multiple spatially separated sites are to be evaluated using a variety of medical responses coupled with a new monitoring design and implementation. The successful proposal should describe statistical analyses that extend the simple approaches used in previous studies. Bear in mind

that the objective of the study is to evaluate causation between the activities of the PGV geothermal plant and health status. The proposal should show familiarity with and consider incorporating in the study modern techniques such as GLM, maximum likelihood estimation, Bayesian approaches, logistic regression, and spatial analysis. The RFP offers the opportunity to incorporate a statistical modeling approach that uses multi-model selection and information-based ranking criteria (e.g., AIC). Since multiple medical responses are to be evaluated, the design should consider family-wise error rate and consider using a multi-way ANCOVA as one of many approaches proposed. Recalling the composition of the proposal selection committee, the proposal should explicitly describe the methods considered. If non-standard methods of the authors' own creation are used, they must be justified, emphasizing why standard methods are not followed.

3. **Sampling**: (a) Randomized sampling is required; however, sample sizes in many of the target comparison groups (communities) will be small. Consider employing stratified sampling and power analysis. (b) Individuals in many of the communities may be reluctant to cooperate with a government sponsored study (see "Public Outreach" below); monetary remuneration for participation will probably be required. (c) The Report placed value on studies directed towards the young, the elderly, the infirm, and Native Hawaiians.

4. **Medical Function Measurements**: The Report emphasizes the importance of measuring respiration and neurobehavioral (CNS) effects. The Report does not stress the degree that CNS methods (e.g., grip strength, balance, reaction time, mood, etc) are not standardized. A successful proposal will address this problem explicitly by proposing to compare existing methods and incorporating recommendations for future studies that assess the long-term health significance of each method (e.g., by comparing "head sway" with longevity). Blood chemistry for stress and anxiety assessment will be components of a successful proposal. Avoid when possible functional tests (e.g., grip strength) in which patient biases towards geothermal development can influence measured performance.

5. **Medical History Data**: Great variability exists in CNS functional response data. Prior attempts to control for this using linear regression were not particularly successful. The slopes of these regressions (e.g., age) are small, the confidence intervals large, and sample sizes small. Nevertheless, insightful proposals will examine co-variates through detailed medical histories including age, sex, smoking, previous health symptoms, education, etc. Additional covariates appropriate to the Puna district of the Big Island include length of time on the BI, in Puna, and in close proximity to the PGV plant; attitudes towards geothermal

development; drug use; diet; obesity and diabetes, and employment status and income level. The study should statistically analyze these medical history data with extensive descriptive statistics and tests comparing communities. These data being essential to baseline studies emphasized in the Report, design medical history and functional studies to be useful to evaluate future geothermal development in the comparison communities. Provide details for archiving the health study database, including provisions for privacy and confidentiality and mechanisms for public access.

6. **Assessing Causation**: The proposal should clearly distinguish between *ambient concentration, exposure,* and *dosage* and relate these concepts to attributing causation to a contaminant source. Causation requires knowledge of exposure: a combination of contaminant concentration and subject location. The blowout of 1991 produced high concentrations, but few measurements were made. The Goddard and Goddard mathematical model of concentration was very simple, and the locations of potential victims during the 36 hours of the event is unknown. To conclude causation based on historical events and current medical test performance is highly questionable. The proposal must explain and justify the procedure to be used. Current concentration data are essential. If new monitoring devices are not in place at the time of the health study, explain your plans to capture independent concentration data and associate those data with subject locations and subject movement patterns.

7. **Final Report**: (a) In addition to normal statistical analysis, for the public's benefit graphically illustrate all results [e.g., functional tests, regression lines (with confidence intervals), medical histories]. (b) Consider circulating a beta-version for public comment and insert the comments as an appendix without committing to altering the original content. (c) Within the constraints of copyrights and journal publication, consider making the final report available on-line.

8. **Public Outreach**: Be aware that many of the residents living near the plant are convinced they are better able to judge scientific quality than the relevant scientific community and have already identified and contacted the only researcher, in their opinion, capable of correctly performing the health study. If you are not this person, then your proposal must describe how you will reach out to the public to gain their confidence and induce those skeptics to participate in the study. Strong convictions of researcher choice should not be present in communities more distant from PGV on the Big Island or on neighboring islands. Consider involving the community by creating an advisory group from a cross-section of local people

including Native Hawaiians to provide historical and geographical knowledge to assist in study design details.

9. **Preparation:** Prior to writing the proposal, familiarize your team with the geography (particularly small-scale depressions where H2S might pool), vegetation, and wind patterns, surrounding the PGV plant. Identifying in the proposal an individual to be a local liaison to advise will be helpful. The reports by Goddard and Goddard, by Hawaii DOH on health effects, and papers by Legator and by Kilburn have greatly influenced the thinking of the community nearest to the PGV plant and some members of the selection committee. A strong proposal will demonstrate an understanding of these documents (see Annex 3: Bibliographic Resources).

10. **What Not to Do**: (a) Do not minimize the research team's past H2S or geothermal advocacy activities; these activities will be scrutinized closely. (b) Do not ignore the inherent statistical variability in the data. Shun "percent of predicted equation" methods that ignore errors around covariate regression lines. See my Briefing Paper in Annex 4: Other Resource Material / Section VI Briefing Papers. (c) Do not use a referent (control) group unrelated to populations on the Hawaiian islands (e.g., Arizona, Texas); this is inappropriate. The Report specifically mentions communities on the Big Island and Kauai that serve as comparison groups. (d) To assess causation, do not ignore the need for accurate measurements of exposure.

LaRee Hiltner

In April 2010, my husband and I retired to this island from Portland, Oregon. In June 2001, I received a Bachelor of Science degree in Civil Engineering from Portland State University in Portland, Oregon and later in June 2006, I received a Master of Science from the same University in Civil and Environmental Engineering.

Before moving here to Hawaii Island, I was not very familiar with the subject of the Geothermal Industry. However, since coming here to this beautiful island, I have been shocked, to say the least, of the environmental and political mess I have experienced concerning this industry. Here we are in the 21st century living in one of the most highly industrialized nations on earth and we have this mess happening here. After examining the past and current monitoring program for the Puna area as it applies to PGV, I find this program has been and is shamefully inadequate. I have heard and read many reasons for this inadequacy ranging from budget issues to low or non-detection of Hydrogen Sulfide gases. There is only one monitoring station currently for the Puna area operating under the direction of the DOH. This is supposedly downwind of PGV. However, it is well known that the winds here in on Hawaii Island can be very variable allowing any toxic dust or gases escaping from PGV to spread out in any direction at any time. As for the other monitoring stations on PGV grounds, these are under the control of PGV.

What bothers me the most about this monitoring arrangement is that everyone involved seems to think this is the proper way to handle the situation. But I realize this may be because of your lack of knowledge, understanding or experience of this industry when the subject of permitting conditions or even to when investigate problems. This, in my opinion, has to change. The change has to be first and foremost in the attitudes of all citizens living and working not only on Hawaii Island but throughout Hawaii as a whole. The change must come especially from those citizens elected to power for they are suppose to guide and protect us in our daily lives by virtue of the laws and regulations they create.

Geothermal development, along with solar and wind power, seems to be the future of our planet as we begin to try and wean ourselves away from oil, gas and coal generated power. Federal laws are often times not up to date with the expanding geothermal industry leaving state laws to protect citizens. However, even state laws can be lacking, leaving that protection of citizens to inadequate county laws. Hawaii Island needs this protection now. The protection needs to be for the health of citizens and the environment not for the profit of all involved. The geothermal

industry is here in Hawaii now and unless we control its expansion in a safe and healthy matter, our citizens and land will suffer.

But in attempting to do so, we come upon a problem. This problem is called "Conformational Bias." In reading an article on the subject (*Review of General Psychology 1998, Vol. 2, No. 2, 175-220*), I came across the very interesting quote from Thurstone (Thurstone, L. L. (1924). *The nature of intelligence.* London: Routledge & Kegan Paul, PG. 101). which states: "If we have nothing personally at stake in a dispute between people who are strangers to us, we are remarkably intelligent about weighing the evidence and in reaching a rational conclusion. We can be convinced in favor of either of the fighting parties on the basis of good evidence. But let the fight be our own, or let our own friends, relatives, fraternity brothers, be parties to the fight, and we lose our ability to see any other side of the issue than our own. .. . The more urgent the impulse, or the closer it comes to the maintenance of our own selves, the more difficult it becomes to be rational and intelligent. (Thurstone, 1924, p. 101)"

This is, as I see it, a very profound statement. It goes to the very heart of the matter at hand. How do we develop and analyze a "Health Study" that removes as much as possible any bias on the part of those involved? I do not profess to know the answer to this dilemma. However, I am beginning to realize that one of the solutions to solving this problem is better communication with the citizens of this island, communication that goes both ways and with more involvement by the citizens, despite bias, to help lessen or remove the problem. As I see it, better communication can begin with better monitoring of PGV and the surrounding areas. This should include a baseline for volcanic activity versus output from PGV. PGV is supposed to be a closed loop system. The reality is PGV is not because of the many "accidents" that have happened over the last 30+ years. Yes, accidents happen. But this many this near a residential community is not good. In fact, it is very bad in my opinion. Please keep in mind I say this with a background in Civil and Environmental Engineering.

The monitoring recommendations we have presented here are what we consider minimum at best. What we need is as complete as possible an understanding of our environment here in the Puna district, one that includes weather patterns, naturally occurring volcanic activity and all events (gases, particulates and sound) coming from PGV. Health studies need this information. Civil Defense needs this information in case of another major event occurring at PGV. EPA and Federal OSHA would also benefit and most importantly, the citizens who wish to have more control over their health would benefit because they could make a more informed decision as to stay or leave in the event of another "leak" from PGV.

What we are suggesting is not hard to do. It will take money and time. But it can be done. We have the technology. But one of the many factors against this happening, as I see it, is the need to make a profit. Why does this have to be at the expense of the health and welfare of our citizens and our environment? You, our elected officials, are supposed to be our first line of defense against industry. It is you we elect to do this.

I would like to suggest, at this point, that at least minimum sampling be done of settled dust in the areas surrounding PGV in order to examine one of the four hypotheses we are recommending, that is, a study of any heavy metal contamination emitting from geothermal energy production sources that may have spread into the soil. This would include sampling volcanic gas vents, in the area, for a baseline and homes where dust may have accumulated from the many "blowouts or major leaks" from events from PGV. This dust should be tested for heavy metals known to exist in all working fluids from PGV and from volcanic activity. These samples should be tested by an accredited chemical laboratory on the main land. The State of Hawaii could ask, as an example, the State of Oregon or California for help from one the state accredited laboratories. The results of this type of testing could give us a minimum baseline, so to speak, of what is out there lurking in our environment for those residents living closest to PGV.

I studied "contaminate transport" at Portland State University in Portland, Oregon. I do understand what solvents and toxic metals can do to our aquifers through the pumping action of wells. My studies at Portland State University included a Superfund site east of Portland in the area of their backup wells. We need to have a basic understanding of what may be harming our citizens. Again, this is not hard to do.

I sincerely hope you read and take to heart all our hard work on this report. We did our best to give you a working report. I know I did. I tried my best to use my knowledge and working experience in engineering and electronics in assisting the group with your request. Thank you.

Robert Petricci

I appreciated being invited to be a member of the health study group. We tried as a group to understand the regulatory protocols and deficiencies, the history of accidents, releases, and exposures, the health issues, cultural impacts, dangers, historic contamination, and other problems geothermal presents to the community. I would like to thank the study group members for their time and expertise.

The first recommendation for geothermal health studies includes a CNS study, and a study of the health impact geothermal may have on Native Hawaiian cultural practitioners.

Hawaii County should implement the recommendations in the report to protect the community's whole interest and health.

The Hawaii county council supported and passed a bill to fund a geothermal health study well over a year ago. Let's hope for everyone's best interest the technical delays and reasons to wait on these studies are now over, and a real-world health study gets done before any more geothermal drilling is permitted.

I am appreciative of the work on monitoring, emergency response, and baseline studies. I think those recommendations were very well thought out and incorporated the things the group discussed. I do not think we did a good job of looking at the effects geothermal has on traditional Hawaiian Pele practitioners. We didn't talk about it until the end and the recommendation I wrote for this particular study is not represented except for a sentence here or there in the report. We should have done better in my opinion, This important study is long overdue and should be done before any more geothermal drilling is allowed.

The report makes an overwhelming case for a moratorium on geothermal until regulatory oversight, environmental protection, monitoring programs, emergency response, baseline health, water, air, and soil studies are addressed.

I believe the report should have called for a moratorium on further geothermal development until the health and safety of the community is assured. I don't think it is.

A moratorium on geothermal expansion until these issues are functionally addressed is critical to protecting the community health going forward.

Recommendation 5 is arguably the most controversial and difficult

recommendation in the report. It makes or breaks the health studies. I want to thank the group and Jim for their patience, understanding, and the time spent trying to protect all the interests involved.

A majority of the public that came out and wanted to be heard were clear in what they said on this point. The residents said consistently and loudly they want a voice in the selection process of who does the health studies. In the end, we were able to involve the community in the selection process in several ways.

First, through a Community Panel that is supposed to represent a cross section of Lower Puna, the RFPs will be ranked. After that, the RFP's would go before the County Council. That allows for public hearings and comments on the contracts.

I believe if the "intent" of the report is followed, it will make a difference in helping to protect the community interest.

Finally one of the things we learned is contrary to industry claims, -- is that geothermal plants like PGV are not actually designed to be true closed loop systems (meaning emission free except during normal plant maintenance). In fact, H2S and other toxins are emitted regularly by PGV during frequent accidents and upsets, as well as during plant maintenance.

90 lbs of Pentane disappears at PGV daily, day in and day out. Where does that Pentane go? PGV says it is not re-injected so where "exactly" is it? Those losses/emissions and many other releases of geothermal contaminants at PGV are considered normal operating procedures, that is not emission free or as a result a real closed loop.

There has never been a geothermal plant able to operate emission free built in Hawaii. PGV for example has had several H2S leaks that we know of just in August of this year.

What many people do not understand, and the high powered PR efforts do not tell the public, is so-called closed loop geothermal systems release a variety of toxins and other potentially dangerous chemicals that can and do impact the surrounding communities. They also impact some Native Hawaiian cultural practitioners. As a result, at the very least until those impacts are understood, regulated, and monitored, there should be no further geothermal expansion in Puna.

René Siracusa

1. Consistency of Geothermal Development with Puna Community Development Plan

The PCDP, which passed as a County Ordinance in August 2008 and is supplemental to the County General Plan, lists as Objectives 2.4.2b and c in the Malama Ka ʻAina section:

> b. Expand the scope of regulations and review procedures for shoreline development to consider dynamic and interrelated potential hazards to development.
>
> c. Strengthen the capacity of the County to identify important shoreline resources and evaluate development regulations and proposed developments in the shoreline area.

These objectives are especially pertinent regarding current plans to site an IDG geothermal plant on the Kealoha property at Pohoiki. The property is sandwiched between two County parks (Isaac Hale and Ahalanui) and these parks are virtually the only place in Puna where there is safe ocean access for residents, visitors and keiki. An industrial use, such as a geothermal plant, is not a compatible land use. Equally important would be the difficulty in conducting an emergency evacuation from the area in the event of well failure, and the high number of children who would be present, including students at Kua O Ka La.

In the Managing Growth section of the PCDP are listed the following relevant Goals (3.1.1):

a. Puna retains a rural character while it protects its native natural and cultural resources. [A geothermal plant and the industrialization it will spawn is not consistent with this goal.]

b. The quality of life improves and economic opportunity expands for Puna's residents. [Neighbors of PGV have repeatedly testified that their quality of life has gotten worse, and that nighttime noise from the plant has caused sleep deprivation and stress, which affects their job performance.]

d. Exposure to high risk from natural hazards situations is reduced. [If we consider the natural causes of some of the PGV upset conditions, and the potential of drilling vibrations to increase fracturing, then siting a plant in a populated area increases the risk.]

h. Incentives for land speculation in Puna. [New geothermal development in Puna increases land speculation. Current regulations, such as Act 97, that were enacted to expand and enable geothermal development, increase speculation.]

Under section 3.1.3 Actions: "Denying zone changes for commercial or light industrial development on sites that are not within designated village/town centers. [Due to a 2012 legislative action, there is no longer a required zone change to site a geothermal plant anywhere at all. The PCDP was written and enacted prior to Act 97, but the intent is clear.]

Section 3.6 deals with Energy Sustainability. Its goals are to achieve energy self-sufficiency by 2020, with a significant percentage of households living completely or partially off the grid. The objectives are to promote the use of solar technologies through various mechanisms, which are listed in the Actions. Although geothermal is mentioned as already in place, it is not discussed as part of Puna's energy future or solution. Also, Puna is not identified as a potential source of any kind of energy production for export to other parts of the State.

THEREFORE, any new geothermal plants proposed for Puna do not meet the requirements of the PCDP, are inconsistent with the plan, and should not be permitted. HELCO should not issue any RFPs for production in the Puna District.

2. Controlling for Life-Style Variables:

During the Working Group's discussions on causality of health effects - i.e., connecting plant emissions to possibility of exposure, to health impacts, the group considered some confounding situations and how to control for lifestyle-related variables. When the health study is designed, it could control variables by:

- control for length of residence as a geothermal neighbor;
- control for distance of residence from plant, and upwind/downwind factors;
- control for smoker/nonsmoker (respiratory impacts) and drug/alcohol abuse (CNS) by testing school children. As the 'canaries' they should be part of a health study anyway;
- it is said that students at Pāhoa schools have a high asthma rate. A health study should verify this with the school nurse, check attendance records and compare absences or 'sent home' data with known geothermal incident dates to see if there is a correlation;

- Pahoa student test scores are lower than average and PHIS was rated #1 in the County in student misconduct. A health study should determine if there is a CNS basis for this and determine whether or not PGV emissions are a causative factor;
- The Puna Community Medical Center's urgent care clinic in Pahoa has noted that it sees a higher number of respiratory complaints than other conditions. A health study should ascertain how many of these are children, so that the data can be evaluated for corroboration with the other controls mentioned above.

3. Improvements in Regulatory Framework:

The permitting process sets the stage for everything that follows, and our studies have shown that a lot of errors and omissions were made with the issuance of the first permits. The State and County had no prior experience, and relied heavily on the assurances of the initial developers, rather than researching rules and regulations elsewhere. The learning process has cost the community heavily.

Baseline Studies: No baseline studies were done before Thermopower (which preceded HGP-A, True, or Ormat) began drilling. Thus we have no firm data regarding air, water, soil quality, ambient noise levels, sources of potable water, health statistics, land values, native species impacts or other relevant data. This lack has hampered our group's efforts to show causation. It is therefore crucial that any future geothermal development that is considered be preceded by a baseline study of environmental quality, health, and standard socio-economic and cultural data.

Best Available Control Technology (BACT): PGV's Geothermal Resource Permit (GRP) requires that they use BACT, and what was BACT at the time was grandfathered in. PGV has stated that they have not updated, because they were not required to. Technology has advanced in the intervening years, but PGV is behind the times. Possibly many of its upset conditions are due to old equipment. Any future permits should require that BACT be the current industry standard and updated regularly.

Siting of New Plants: The recent accident at a propane plant on the mainland, where one person died and many others were injured, and that required the evacuation of about 50 homes, highlights the need to site dangerous industries away from residential areas. Recent health studies from Iceland and New Zealand provided to the working group re-enforce this caveat, as of course do the 20+ years experience of the PGV neighbors.

Failure of DOH to Protect Public Health: Athough some working group members brought cynicism about the Dept. of Health to the table, others soon learned that

DOH has not fulfilled its mandate to protect public health: PGV incident reports sent to them did not result in follow-up, no East Hawaii investigator has filled a long vacant position, no records were kept of earlier health studies, etc. Although the EPA has primacy in Underground Injection Control (UIC) they have delegated it to DOH, which has failed to do its job regarding the unlined sump ponds. To improve the regulatory process it is imperative that the EPA be asked to revoke that delegation and resume primacy. The DOH should also be urged to reconsider the noise level standards for agricultural zoning based on updated scientific studies and to reflect the precautionary principle - should a health study show that residents are stressed from excessive noise and sleep deprivation due to current noise levels, DOH should revise these downward before any new permits are issued.

Restoration of Citizen Input into Regulatory Process: When the right to a contested case hearing was legislatively removed in geothermal cases, and replaced with an ineffective mediation process, the first nail was hammered into the coffin of public participation and transparency. In 2012, when the State legislature passed Act 97, the coffin was lowered, covered over and the soil tamped down, and the County joined the public in being denied input on future geothermal development. County zoning, permitting, General Plan, local control over designing our future, all went into the hole. I urge the County administration to renew its efforts to restore home rule to Hawaii island by working with the community and our legislative delegation to revoke Act 97. Until that is done, all our plans to create a pono, safe and healthy future are meaningless, and new geothermal development can sprout up anywhere and do what damage it will for the sake of their stockholders' bottom line. That is not acceptable.

Finally, I want to thank Puna Pono Alliance for its efforts that resulted in the convening of this geothermal health study working group and to County government for agreeing to and funding the process. I want to thank Peter Adler and his staff for all their hard work and, of course, my fellow working group members. We did not always agree on everything, but we focused on issues and not personalities and all put a lot of time, energy, and mental effort into the process. MAHALO NUI LOA AND MALAMA PONO.

(The following further addendum was received on September 6, 2013 from Rene Siracusa who was unable to join the Study Group for its final meeting on September 1, 2013.)

"Due to last minute editing changes, some of the Rec. #7 suggestions were omitted. These include identifying special needs residents for notification and evacuation assistance; HCCD should work with community groups so everyone knows what the evacuation protocols and route are; HCCD should do annual

community drills. Under Automatic Alerts, plant personnel should not be relied on, as their first priority is to address the problem. The computer program attached to the monitors should automatically alert HCCD, the community, and all emergency responders. The Community Response Partners should also have hand held monitors, in whose use they are trained, so that more reliable data can be gathered. HCCD has recently installed a siren in Leilani (see 3. Sirens) and plans to make a change so that it can operate independently of the island-wide system, with a special sound for geothermal incidents. Under 4. Interim Measures: "Until such time as HCCD can ensure that the [PGV plant] Leilani siren..." . These two became reversed in the editing process."

Jeff Sutton

The Hawaii County Geothermal Health Assessment Study Group has been one of the more challenging and in some ways more rewarding committees I've been involved with during my twenty years in Hawaii studying volcanic processes and hazards. It has been challenging, because of the tremendous volume of material and history to understand, and rewarding because of getting to work with such dedicated, passionate, and tireless community individuals, and to have the chance to help make a difference.

I commend the mayor for convening a local and diverse joint fact finding panel to provide him with distilled information on pressing Hawaii geothermal health issues, and with recommendations on how to better protect the health of County residents who are negatively affected by current geothermal development, or might become so by future geothermal expansion.

Interestingly, while modern geothermal research and resource development began and proceeded on one part of the island, the thirty-plus years of Kilauea's ongoing east rift eruption has, for bad and good, provided Hawaii public officials, residents and visitors a body of continuous experience in dealing with the direct effects of volcanic pollution on agriculture, communities, and infrastructure. An entire generation of Ka`u and Kona residents has effectively been born and raised in Kilauea's east rift plume cloud, while others have grown old, and some are long gone.

Even before the opening of the new vent within Halema`uma`u in 2008 though, residents of Hawaii Island had developed a voracious appetite for understanding how volcanic emissions (vog) from the eruption was affecting their health.

Owing to the anecdotal reports of vog-induced headaches, flu-like symptoms, stinging eyes, and breathing difficulties, the public appealed to officials for health studies that could systematically and scientifically measure and document these effects. In those early years, several vog-health studies were carried out, that at best, were marginally successful.

A primary contributor to the poor quality of early vog-health effects studies was that the researchers conducting them failed to adequately engage the communities they were studying, and investigators also neglected to fully consider the physical science—principally the meteorology and volcanology—of Hawaii Island. The fruits of their labors amounted to several half-baked health studies that missed the

mark, along with years of wasted time, money, and most importantly, citizen health.

More recent vog-health research, funded and guided by the National Institutes of Health (NIH), the Centers for Disease Control (CDC) and the American Lung Association of Hawaii (ALAH) underscored the importance of community-based health research. This approach relies on integral involvement of the communities being studied from the get-go. Accordingly, these communities "bought-in" to the studies because they were involved in designing and conducting them. In addition, the health studies principal investigators teamed up with local physical scientists (meteorologists at the UH, and volcanologists at USGS-HVO) to better understand the nature of the volcanic hazard, along with the importance of meteorological factors.

The result of the close working relationship between physical scientists, health studies workers, and community members has been a story of remarkable success. The elementary school students who joined the study years ago, along with their families, have stayed the course by staying involved. Many have now graduated from high school but are still involved in helping find out the effects of prolonged exposure to volcanic emissions on human health.

Community members, along with scientists and health studies professionals have stayed involved in vog-health studies because they all have a stake in the outcomes of this work. The vog-health studies are producing results, and the community members are right there to receive those results.

The same potential for success can be expected for health studies related to the effects of geothermal development and associated emissions on health. The people of Hawaii Island, especially those living near current geothermal development, have demonstrated not only a thirst for understanding regarding geothermal health effects, but a willingness to participate in the studies that would help establish that understanding.

People who choose to live in Hawaii do so for a variety of reasons; a primary one is to be close to the land and the ocean—specifically, land and ocean that is unspoiled by overdevelopment. People living here either actively or tacitly accept the risks associated with living in a volcanically active area. Although eruptive changes happen, Hawaii residents accept the fact that one of the world's most active volcanoes was here before they arrived.

Many Hawaii residents, however, who willingly accepted the volcanic health risks didn't bargain for the health risks associated with geothermal development. This development is under human control, and came about upwind of communities that

were already there. To date, the human-generated risks are poorly understood, and by itself that constitutes a huge problem. Fortunately though, it is one that can be addressed, and the Mayor has expressed a will to do so.

The concern voiced by county residents regarding the poorly understood geothermal health risks is commendable, because citizens who understand both the hazards and risks around them can take control of their own lives and make informed decisions to protect their health and that of their families.

In the (short) twenty years that I've lived here, I've seen that Hawaii Island residents are, on average, very much engaged by their surroundings. They want to understand the world around them; that's why they're here.

The Mayor and the County Council said that they wanted to be advised regarding the goals for health studies that needed to be conducted, what information about geothermal development and its relationship to health needed to be gathered, and what additional monitoring needed to be done, to better protect Hawaii Island's residents.

This report, prepared by engaged Hawaii residents is arguably the best step to date, towards the Mayor's request. But currently this report is still just advice. And at best, even really good advice is only worth something if it's acted upon faithfully.

So at this point, we committee folks can do little more than take our places with the rest of the community to keep the recommendations that the Mayor asked for on his and the County Council's radar. Imua!

Laura Travis

I believe that I should be allowed to live in a clean place in a clean way, being as sustainable as I can. I want to breath fresh air, feel safe, raise my own fruit, and take joy from the beauty and graciousness of the land of Hawaii.

I believe that my government should protect the health and welfare of its people, being especially careful for those that cannot protect themselves.

I believe that industry should not be allowed to profit off the backs of those that live nearby.

This report makes it clear that others do not share or are not acting according to those beliefs. I cannot understand how for over thirty years we can take risks with the health of our people, and not take action to understand or lessen that risk. I do not understand how people are forced to move and beautiful important sites are destroyed so that an industry can make profit and wealthy landowners can get return on investment.

This report calls for action. That action needs to be taken now. And further geothermal development should not be allowed until we have addressed the problems already created, until we have built a regulatory structure that reasonably addresses where to place and how to operate geothermal plants, and until we ensure the health of our people rather than the financial health of geothermal developers.

Thomas Travis

sacrifice |ˈ sakrəˌ fī s|
noun
an act of slaughtering an animal or person or surrendering a possession as an offering to God or to a divine or supernatural figure: *they offer sacrifices to the spirits* | *the ancient laws of animal sacrifice*.
• an animal, person, or object offered in this way.
• an act of giving up something valued for the sake of something else regarded as more important or worthy: *we must all be prepared to* make sacrifices.

Several tradeoffs become confused when discussing geothermal in Hawaii. Some ask if geothermal is more friendly to the environment than oil and gas. The answer is probably yes. Some ask if geothermal is cheaper than the petroleum based fuel used for electrical power generation. The answer is usually yes, depending on the price of the petroleum based fuel. Some ask if geothermal can be produced safely. The answer is that there are risks with geothermal, but with a thoughtful regulatory framework, thoughtful plant placement, high engineering standards, and careful operation the answer is that the gain can be greater than the risk. Some ask is geothermal good for the community. The answer is that geothermal brings nuisance, intrusive noise, increased health risk, and cultural stress to the community in which it resides.

Trying to weigh these issues, the question of "place" becomes important. What is the community's "place" in the chain--research through development through production through use--of geothermal energy. Geothermal energy might be a positive to a user far from a plant but a negative for someone who lives off the grid next to the plant.

This all brings us to the question of "sacrifice". When is it ok for a government to sacrifice a community for the good of the whole? My answer is ***never***.

The government has tools--purchasing property through use of eminent domain, zoning regulations, noise regulations, tax structures, and health investments--to mitigate the negative impacts and create positive effects on the community.

How do the State of Hawai'i and the County of Hawai'i stack up against this standard as regards geothermal along the East Rift Zone in Lower Puna? Not well.

This report documents that the Department of Health:

- Has set inappropriate limits for very short term exposure to H2S. It is probably possible to kill someone with H2S and meet the State's limit.
- Has accepted an inadequate monitoring system to enforce the limit it has set.
- Has allowed geothermal operations to effect the health of the community.
- Has systematically failed to "pin down" the effects of H2S from geothermal in health studies in the last two decades.
- Has not followed the precautionary principle, that is: until something is proved safe, it should not be done.
- The report documents after 37 years of geothermal, the County:
- Has not developed a notification procedure appropriate to the risk of geothermal.
- Has not developed a list of vulnerable sub-populations for early action in an accident.
- Has not developed noise regulations that allow neighbors to geothermal production to have the same noise protections as people at home in Hilo.
- Has not systematically addressed the cultural stress presented to Native Hawaiians who feel violated by geothermal operations.
- Has not sponsored or financed studies to "pin down" the health effects from geothermal emissions.

More could be said, but the point is clear. Whether with intent or not, the State and County have become part and parcel to business and industry forces that want to sacrifice a community and its residents. It is time for leaders in the County and State to step up and step clear of the long history of government in Hawaii supporting special groups at the expense of community.

2 Public Comments

A. Comments Submitted Electronically or Scanned from Letters

First Name:	Janette D.
Last Name:	Sherman, M.D.
Email Address:	toxdoc.js@verizon.net
Phone Number:	Alexandria, VA
Comment/Question:	I am the physician who did the original study of some 75 residents that were exposed to the geothermal releases. All of my data, reports, background materials, extensive bibliographies and spread sheets are archived at the Library of Medicine. I have contacts here in the DC area who could go to the Lib. of Med. and copy the materials. I est. it would cost @ $35./hour and could be done within a full day or so. The information can provide the health status for a point in time so that you can make comparisons. Wouldn't this be less costly than re-inventing the wheel?

5 August 2013

Comments on the Adler Group Geothermal Public Health Assessment Findings and Recommendations

1. The report is very well written and does a reasonable job of identifying problems and providing recommendations. A major concern would be that it will be filed away on a shelf without implementation. Hopefully, a private/public partnership can be formed to implement recommendations. Specific comments on findings and recommendations follow.

Finding: Geothermal operations carry health risks. This is followed by a recommendation to perform a meta-analysis of health issues associated with H2S releases. Please note that, at the behest of the EPA, a National Advisory Committee for Acute Exposure Guideline Levels for Hazardous Substances (NAC/AEGL Committee) has already performed an extensive meta-analysis to

establish H2S Acute Exposure Guideline Levels (AEGL). The relevant document can be found on the EPA website when one searches for "AEGL for selected airborne chemicals, Volume 9. " Item #4 is Hydrogen Sulfide. The AEGL meta-analysis addresses relatively short term (up to 8 hours) exposure effects, so any follow-on meta-analysis should focus on long term exposures.

Appendix A of the NAC/AEGL Committee document presents time-scaling calculations for H2S, to include derivations of AEGLs 1, 2, and 3. The scaling is done using a version of the Haldane Equation: $(C^{**}n)^{*}t = k$,

Where *C* is concentration, *t* is time and *k* is a constant. The Haldane Equation is essentially a simple power-law model that establishes an equivalency between sets of exposures at selected concentration-time combinations, with *k* being a measure of dosement (or toxic load) in ppm-hr or equivalent units. The NAC/AEGL Committee find exponent *n*, derived from various experimental data sets, to have a magnitude of 4.4 on *C* (its inverse 0.227 on *t* provides identical results). While the derivation results presented for AEGL-2 and AEGL-3 are more-or-less correct, the derivation of AEGL-1 in Appendix A contains multiple mathematical errors. Constant *k* for AEGL-1 should be 10.556 ppm-h, not 10.27 ppm-h. Also: 2.6/3 is 0.86 (not 0.75), 2.0/3 is 0.67 (not 0.60), etc. The correct AEGL-1 values are:

10-min	30-min	1-hr	4-hr	8-hr
0.86 ppm	0.67 ppm	0.57 ppm	0.42 ppm	0.35 ppm

Atmospheric dispersion modeling (ADM) results can be compared with AEGL data to determine whether or not residents in communities surrounding PGV have been or are potentially subject to toxicologically significant concentrations of H2S gas over a selected time span. Long-term exposures (greater than 8 hours) may not follow this Haldane Equation and require separate analysis.

That geothermal operations carry health risks is not a new conclusion. Appendix H of the PGV Emergency Response Plan contains considerable detail on hazardous conditions that might occur during "upset" scenarios. This is the best information currently available, and should be used as a basis for emergency response until a new modeling program is completed using an up-to-date ADM.

A final note on health risks. Hydrogen sulfide is certainly the greatest PGV health risk and deserves major attention. Risks posed by other chemical species are likely to be secondary. Of these secondary concerns, silica in particulate form should be assessed as a health risk. Silica may enter the

atmosphere as it is scraped from deposits within piping or if it is improperly stored or transported. It is not mentioned in the report.

Recommendation. Establish a better monitoring system. It is essential that everyone working on this issue understand that monitoring is not equivalent to measuring. Any release to the atmosphere entrains along a Lagrangian trajectory determined by the turbulent wind field into which it is released. Measuring equipment, unless tetroon-mounted to follow the release, will essentially measure gas concentrations at a finite number of fixed positions (an Eulerian frame of reference). A detector can only sample its surrounding atmosphere at a rate of a few liters per minute, while a toxic cloud may be anywhere within a volume of millions of liters. Toxic gas clouds are not constrained to pass through any fixed sampling array, and often pass over or around any such array. Even if a portion of a toxic gas cloud is sampled, there is no way of knowing if this is a maximum (near centroid) concentration sample or simply a brush-by. In short, sampling arrays cannot be relied upon to adequately monitor toxic gas releases into the atmosphere. No reasonable number of measurement devices can be installed around PGV to adequately monitor the site. Further, measurements produce data points. What we need is information. The conversion of data into useful information occurs through modeling. Models produce the information upon which reasonable decisions can be made.

The only reasonable way to monitor toxic gas releases to the atmosphere is with an appropriate atmospheric dispersion model (ADM). The ADM has a hierarchy of measurement requirements: first, a properly characterized source term; second, a well characterized wind and turbulence field; third, an array of samplers (mainly for personnel protection and verification of ADM performance). The source term includes the types and quantities of materials released, release rate and duration, release configuration, volume, velocity, direction, and heat content (for buoyancy considerations). A description of the terrain, vegetation, structures, etc. at or near the release site is also useful. Any meta-analysis of health effects due to past and possible future releases must include well characterized source term for each release.

Meteorological requirements for a monitoring program include both characterization of the flow field (showing which way the toxic gas is going) and characterization of turbulence (indicating the rate at which gas is being diffused). An additional meteorological variable of considerable importance is the mixing height, which defines the vertical dimension of the volume into which the gas can be dispersed. In the absence of on-site measurements, a prognosis of the 10-m flow field is available using the WRF model that runs continuously on the Maui supercomputer (http://weather.mhpcc.edu). This information can be ingested directly into an ADM. Adequate on-site wind and turbulence measurements can

be obtained using tilt-up 10-m towers, which are orders of magnitude less expensive than 40-m towers. These sorts of details should be determined by a body of experts convened to define the monitoring program.

Any PGV monitoring program will likely include H2S sampling. Hydrogen sulfide samplers come in two basic categories: personal protection gas detectors and fixed site samplers. Hand-held personal protection detectors typically have a range that spans 1 – 100 ppm with a resolution of 0.1 ppm, cost about $300 – 500 each, last about 2 years, have a sampling rate on the order of 10 seconds, and come with some limited calibration and data download capability. These would be good devices for Hazmat/first-responders to carry as they respond to a toxic gas release. Fixed-site samplers (Jerome, for example) can detect H2S concentrations to within a few ppb, cost on the order of $10,000. each, are mounted at fixed sites, and should be coupled with a data acquisition system for continuous monitoring. A limited number of these samplers could be placed at strategic locations as part of a warning system. The costs and effort needed to operate and maintain these samplers and archive/display the data are substantial. Again, sampler requirements should be defined by a body of experts.

Concerning experts, the category "certified monitoring expert" does not exist. The American Meteorological Society offers the emblem "Certified Consulting Meteorologist," but this certification by no means indicates that the person in question is able to design a measurement program, interpret ADM results, or understand dosement concepts. A search would be needed to find someone with a reasonable education (at least M.Sc. in the field), relevant subject matter publications, and field experience.

Recommendation: Strengthen public communications and alerts. First responders need to know two things as soon as possible: (1) the magnitude of the problem; (2) the toxic plume's direction and speed. To know these things they require the source term (described earlier) and current wind/turbulence conditions processed through a real-time ADM. The ADM can provide a real-time contours of the gas concentration field and a depiction of how the gas is dispersing as it moves downwind. Modern ADM also provide probability of exceedance, an extremely valuable decision-making tool that takes the guess work out of hazmat asset placement and evacuation decisions.

Several low-cost/no-cost changes are needed to produce a credible hazard response capability. First, the "watch" and "warning" standards must be based on averaging times relevant to the potential hazard. A toxic cloud emanating from PGV can envelop a nearby community within a few minutes. An effective hazard response must be on a commensurate time scale. Hourly averaged standards are

fine for regional scale events such as monitoring acid rain in New England due to effluent from coal-fired power plants in Tennessee. Hourly standards are not appropriate for PGV and its surrounding communities. Using the Haldane Equation with the EPA-derived exponent for H2S, a 1-hour standard of 25 ppb is toxicologically equivalent to a 1-minute reading of 63 ppb. Adding sub-hour time scales to the standard (and also to the meteorological measurements) would allow first responders to issue timely warnings in the event of an "upset" condition.

The second change needed is public engagement. With some minimal training, members of the public should be able to access and interpret plotted results from an on-line real-time dispersion model. Such training must be an integral part of the implementation phase. This would also instill public confidence in monitoring procedures.

The third change involves incident/upset condition reporting. The initial report from plant operators must include as much information as possible about the source term. If the source term cannot be measured or estimated, Hazmat/first responders should choose one of the twelve upset scenarios presented in Appendix H of the PGV Emergency Response Plan that best fits the upset condition. If nothing is known, default to the worst case scenario (maximum credible event) using results from previous model runs (also available in Appendix H). The ADM can then be re-run as the source term and meteorological conditions become more clearly defined.

As a final note, the County of Hawaii is unlikely to have the resources necessary to "take the lead" in implementing recommendations, especially those that involve technical issues such as monitoring. Public health and safety are fundamentally State issues, and cooperation from the State Department of Health is crucial. The State receives substantial royalties (geothermal asset funds) from PGV operations. Those funds should be used to develop adequate monitoring and emergency response capabilities. The State is also in a better position to require the cooperation from PGV operators and to draw on assets available at the University of Hawaii and the Department of Energy. The findings and recommendations identified in this public health assessment can be resolved if all concerned parties are willing to work together in a public-private collaboration.

Christopher A. Biltoft
Adiabat Meteorological Services
biltoftc@yahoo.com

First Name:	John
Last Name:	Petrella
Email Address:	john@hilojohn.com
Phone Number:	808-640-3953
Comment/Question:	Thanks for a solid report! I would like to share the following thoughts or questions... 1) Are there any health studies on the operators of this power plant? (and other power plants of similar nature.) 2) Fluid dynamics may be a better way to model any H2S release (think of water from a fire hydrant streaming or blowing up into the air). 3) Statistically separating residents near this plant from the residents on the other parts of this island would be like pulling two gold fish out of their fish bowls and then trying to determine which fish is wetter. 4) The recommendations of this report seem to center on what can be measured by some instrument or transducer. I would like to point out there is also observational science and perhaps other data that can be very reliable and in some cases better than a mechanical or electrical transducer or computer models. Has any one asked or answered: Where or what is the canary in this mineshaft? Do we have mutated birds and frogs? (Frogs in particular are very sensitive to environmental and chemical changes). Did certain plant species quit growing? Was a certain species replaced in the last 40 years by another more hearty species? In other words if there was or is damage would It not be reasonable to assume there was or is damage to other living creatures? Comment 2 Puna is roughly 500 sq miles in size. It goes from the ocean to rain forest. However, population numbers are not hard to find. It has more CDPs (census designated places) then the other districts on Hawaii Island. The data are current as of 2010. The CDPs are: Ainaloa, Eden Roc, Fern Acres, Fern Forest, Hawaiian Acres, Hawaiian Beaches, Hawaiian Paradise Park, Keaau, Kurtistown, Leilani Estates, Mountain View, Orchidland Estates, Pahoa and Volcano. The Discussion on page 34 could be made better by adding the number of people living in concentric circles (using an increment of 1/4 miles) of the power plant. Also the number of people living in the prevailing down wind pattern and down slope of the plant should be addressed. The reason being is that H2S is heavier than air. Sure it will disperse in a wind but its chemical nature is to sink or flow towards lower ground.

Comment 3

Much of the report centers around H2S emissions from the power plant. Missing from this discussion are the quantified emissions of Kilauea. No mention is made of the amount of H2S being emitted from Kilauea. No mention seems to have been made of (Hydrogen Fluoride). Kilauea emissions have been well studied. For example, Symonds, Rose, Bluth, and Gerlach (1994) published a list of compositions of high-temperature volcanic-gas samples. The measured Gases from Kilauea are: H2,CO2,CO,SO2,H2S,S2,HCl,HF and COS. HF is emitted at rates between 7 to 12 tonnes/day from Kilauea. Fluoride is deposited on the leaves downwind vegetation and is not metabolized by plants. Animals (and humans) eating the tainted forage can get fluorosis and ultimately die if the fluoride amounts are high enough. Very few studies have been done on fluoride content in Hawaii vegetation around Kilauea. Symptoms of Fluorosis Learning Disorders/Difficulty Concentrating/Incoherence/Memory Loss/Confusion Body Temperature Disturbances/Cold Shivers Chest Pains Heart Palpitations Depression Dizziness/Vertigo Dyspepsia Excessive Sleepiness/Fatigue Headaches/Migraines Joint Pains Nausea Restlessness Sensitivity to Light Shortness of Breath Difficulties Swallowing Thirst Tinnitus Visual Disturbances

There is a excellent body of scientific work on trace element concentrations (parts per million) from the surface flows, tube flows and vent splatter. These measurements were made from 1983 to 2001. The elements measured are: Rb Sr Cs Ba Th U La Ce Nd Sm Eu Gd Tb Ho Tm Yb Lu Zr Hf Ta Sc Cr Co Ni Zn Please see Trace Element and Nd, Sr, Pb Isotope Geochemistry of Kilauea Volcano, Hawai'i, Near-vent Eruptive Products: 1983 – 2001 By Carl R. Thornber, James R. Budahn, W. Ian Ridley, and Daniel M. Unruh This should be part of the discussion of what we know vs what we do not know.

Please add to the discussion the following: Volcanic plume samples taken in 2008 and 2009 from the Halema'uma'u eruption at Kilauea show concentrations elevated above background air of Rb, Cs, Be, B, Cr, Ni, Cu, Mo, Cd, W, Re, Ge, As, In, Sn, Sb, Te, Tl, Pb, Mg, Sr, Sc, Ti, V, Mn, Fe, Co, Y, Zr, Hf, Ta, Al, P, Ga, Th, U, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Er and Tm. source: Mather, T. A.; Witt, M. L. I.; Pyle, D. M.; Quayle, B. M.; Aiuppa, A.; Bagnato, E.; Martin, R. S.; Sims, K. W. W.; Edmonds, M.; Sutton, A. J.; Ilyinskaya, E., 2012: Halogens and trace metal emissions from the ongoing 2008 summit eruption of Kilauea Volcano, Hawaii. Geochimica et Cosmochimica Acta 83: 292-323

Comment 4

Numbers in this report always should have a reference. The emissions

	addressed in the discussion should also reference the "normal" emissions of Kilauea. For example prior to 2008, Kilauea produced about 270 tons of mercury each year and has been identified as a source of mercury on Oahu, 320km away. (Siegel and Siegel, 1987). 0.36 pounds/per month from HGP-A is 4.32 pounds a year or 0.00216 tons a year. In other words Kilauea produces 125,000 times more mercury. (calculations based 1 ton = 2,000 lbs). Common symptoms of mercury poisoning include peripheral neuropathy (presenting as paresthesia or itching, burning or pain), skin discoloration (pink cheeks, fingertips and toes), swelling, and desquamation (shedding of skin). Mercury irreversibly inhibits selenium-dependent enzymes (see below) and may also inactivate S-adenosyl-methionine, which is necessary for catecholamine catabolism by catechol-o-methyl transferase. Due to the body's inability to degrade catecholamines (e.g. epinephrine), a person suffering from mercury poisoning may experience profuse sweating, tachycardia (persistently faster-than-normal heart beat), increased salivation, and hypertension (high blood pressure). Affected children may show red cheeks, nose and lips, loss of hair, teeth, and nails, transient rashes, hypotonia (muscle weakness), and increased sensitivity to light. Other symptoms may include kidney dysfunction (e.g. Fanconi syndrome) or neuropsychiatric symptoms such as emotional lability, memory impairment, and / or insomnia.

First Name:	Catherine
Last Name:	Ridder
Email Address:	caridder2@netzero.com
Phone Number:	626 485 2829
Comment/Question:	I live on Pohoiki rd. (13-382). I rent it out to guests as well. Evacuation, safety and air and water quality are serious concerns of mine. Protect the well being of the people and the land!

First Name:	Avery

Last Name:	Freed
Email Address:	averymfreed@gmail.com
Phone Number:	808 9370742
Comment/Question:	Stop this poisonous assault on our puna residents. The Adler report is not complete. No mention of cultural impacts, or of baseline studies as recommended by the prestigious Union of Concerned Scientists. Is the geothermal group as scientifically trained or informed as the UCS. Of course not. The geothermal industry must be held accountable for any damage to people and property. As a physician I was held responsible for harm I caused patients. Geothermal should not hide responsibility by an LLC shell game. The supreme court ruled that corporations are like individual. I think there is a strong possibility that escaping through loop holes, LLCs, and other tricks will be judged unconstitutional by the US Supreme Court. I request that Dr. Kilburn be hide for his expertise. If he is not hired, I would like to know why he is not considered professionally qualified. Mahalo Dr. Avery Freed Opihikao

First Name:	Leslie
Last Name:	Wingate
Email Address:	Lesliewingate7@gmail.com
Comment/Question:	After reading through the report, it is clear that past monitoring efforts, regulatory control, and past emergency response have been inadequate, and actual health impacts have not been properly studied. Additionally, it would seem that the State limits on H2S exposure based on hourly averages are insufficient to protect the public. I believe these conclusions should be stated explicitly and forcefully in the Executive Summary. I want to see a health study done by Dr. Kilburn ASAP The attached draft known locally as the "Adler Report" is over one hundred pages long. That is really long for most people to read, as we are mainly very busy caring for our families and enjoying the natural beauty that surrounds us here. A natural beauty that has already been destroyed in most places on the planet. Finding a place where you can raise your children in a place with clean air and water is a challenge these days! This place is extremely unique and needs to be protected from heavy industry. It does not belong here is this place. I have identified the following areas I, and others in the community,

believe deserve attention. Dr. Kilburn was chosen by the community as the researcher of choice to do a Puna Health Study on H2S. Instead of doing the study the mayor decided to create the health study group led by Peter Adler. The mayor has repeatedly shown us that he does not listen to the community of Puna or respect our wishes. He is not representing the people and protecting our health. I believe Dr. Kilburn is a respected and trusted researcher and the report should explicitly recommend that he lead the effort. On page 14 the report speaks of a mandate that prevents specific recommendations. I can find no such written mandate. Who mandated this and in what forum? The Legator Study is not mentioned with the other studies about geothermal in Puna. (Health Complaints, Finding 2, Page 35 and following) Additionally the Legator Study is not in the Puna specific health studies in the bibliography. It should be included in both portions. Dr. Legator did serious health studies in our community. Legator did his study on the Puna residents, we believe that should be noted in the report. Please include this in the report. In the Initial Interviews section (page 15), one narrative that was not mentioned is the outrage by Native Hawaiian Pele Practitioners. That could be called the Cultural Impact Narrative. Additionally in Recommendation 1, page 42, this outrage is not discussed as part of the cause of possible health effects that are being examined, even though it clearly should be. Anger and the feeling of being taken advantage of and having your culture destroyed is a huge source of dis-ease. Not only for native Hawaiians, but also for those that come from the American (lack of) culture. I very much appreciate the Hawaiian culture and feel very sad at what has happened to their culture and how that effects the lands and people that are around where I live. The report makes no mention of baseline studies being required for future geothermal development. Even though I don't want to see any future geothermal development in Puna, I still think its important to have baseline studies so that we have information to have as a foundation to go from in making decisions. Such studies are recommended by most groups that study geothermal development (e.g., Union of Concerned Scientists) and environmental groups like the Sierra Club. The health study group had also recommended these baseline studies be included but there was an error somewhere and they were excluded. We want them back in. We need baseline studies, please include this in the report. Recommendation 5 (Assure credibility, reliability, independence of experts) is long and complicated. Too complicated for the average person to want to read! It is also probably unworkable in that informed, concerned members of the community probably already have an opinion! I'm tired of seeing these words thrown around lightly, and not used with integrity. The impacted community should have a stronger voice in the selection. Why not let our community submit a

	recommendation for the study to the County for approval? In my personal experience, the idea that the county wants an "open, objective, and scientifically valid" selection does not reflect past historical outcomes of county interactions with the community on geothermal matters, or any matters for that matter :-) The criteria for evacuation of community members currently is inadequate and Recommendation 7 (page 58) does not discuss this issue. Especially important is the identification of the at-risk individuals and the setting of limits to protect them from potentially harmful exposures. The means for evacuation of the most seriously threatened individuals is not well laid out in the current emergency response. This is not discussed in Recommendation 7, page 58. The public wants a clear and concise emergency response plan that protects the most seriously threatened individuals. I want to know what the current emergency response plan is. From what I've heard there is not a plan at all. Is that true? Look at what has happened at Fukushima, it is continuing to get worse and put radiation and pollution into our ocean, because it didn't have an adequate plan for what would happen in an earthquake. This is a very serious example of why it is so important to have a good plan, and in my opinion, to shut down the plant until these concerns are addressed. This area is very unstable and prone to earthquakes. PGV has had 20 yrs to get these things, that will protect our health, in place, and I believe its is our responsibility to demand the cease of PGVs operations, until these concerns are addressed. We are only asking them to operate safely and stop making people sick. Although, its starting to seem as if it might be in a neighborhood so as to specifically have the purpose of making people subtly sick and therefor easier to control and subject to the expensive and inadequate medical system. Why else would PGV be within 3000' of residences when there are other places it could be?

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Comment/Question:	In Dr. Adler's latest report, which could be subtitled "Leaving Puna High and Dry," he wrote a long report which somehow managed to omit several items that had been gone over numerous times at their meetings, in what is referred to now as "Geothermal War 2." The good doctor must have been suffering from a sever case of oversightitis. 1: A particular group of individuals have been calling for a H2S (hydrogen

	sulfide) study done by K. Kilburn, an independent authority on the subject; however, page 14 of the report mentions a mandate that prevents specific recommendations. What is interesting to note is no mention of this mandate can be found anywhere else. If I didn't know better, I'd swear someone specifically didn't want a Kilburn study. 2: The Legator Study is not mentioned at all. Why is this? It needs to be in the report. 3: Native Hawaiian Pele Practitioners were ignored on the report, leaving out the cultural aspect. It needs to be there. This is Hawai'i and strangely enough Native Hawaiians are the most neglected cultural group in the state. Many of them believe drilling into Pele is a sacrilege, but those standing to benefit from the fracking (call it what you will, it's still fracking) will overlook the Native Hawaiian cultural aspect. 4. A baseline study was never done, something that makes it easy for industry to skate out of it when something hits the fan, as they will claim it was always that way, no matter what they may have done. Scientific and environmental groups all recommend them, but somehow it was left out, like a number of other important features. A baseline study is needed before any more drilling is done, something the industry will do anything to prevent. 5. Assuring the credibility and independence of concerned members of the community is impracticable, as those individuals are more than likely already biased one way or the other. Those who live in the Puna District should have more of a say in what happens in their district regarding industrialization than someone who resides on Mount Olympus and is hired by those who live nowhere near the affected area.

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Comment/Question:	Regarding Puna geothermal: Aloha, Thank you all for putting so much effort and care into this. Our only comments are: Page 44 line 28 points out that vog is unusual in Puna. This contradicts what was said earlier about there being variable winds in Puna when relating to the geothermal plant and potential monitoring sites. Variable is what the winds have been in Hawaiian Beaches and Waʻa waʻa. We are on the "windward side" downhill from the plant. We lost our steady, strong trade winds 5 years ago and get frequent swirling winds, west or southwest winds, particularly at night. We and our neighbors began to

	have CNS symptoms exactly like the ones mentioned in Dr. Adler's preliminary health study. Recommendation 1: Page 45 line 44 - should include all communities surrounding the plant, including Hawaiian Beaches, Waʻa waʻa, Koaʻa. We are all experiencing the same symptoms. Recommendation 2: What in the world happened to past recommendations? Is it possible to make this sound stronger and make sure that there is follow through? The word MUST is used several times throughout the document, but usually a recommendation is preceded by SHOULD. I think everyone pro or anti is in agreement that the monitoring, evacuation plan and warnings, and the studies are necessary. Could shall or must be used instead of should? Question: We were just reading that elevated levels of thiosulfate in the urine is found in people exposed to H2S, particularly people exposed in long term, low level situations. It seems that if people come to the clinic with low level H2S symptoms, they could be given a urine test and this could be part of the health monitoring for our community. Mahalo nui loa, Sherry and Rex Palmer

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Comment/Question:	A good report. Since all forms of energy production involve some hazards, I think it would be useful to compare the potential hazards of geothermal with those of other types of energy production: fossil fuels, biomass, solar, nuclear, etc.

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Comment/Question:	Testimony of Paul Kuykendall Email: bigislandpaul@gmail.com Aloha. My name is Paul Kuykendall. I would like to begin by thanking the members of this study group for taking significant time and energy to develop this report. You have done a tangible and useful service to our community. I know it hasn't been easy. Mahalo. I appreciate your general findings and recommendations. These recommendations are not only a list of what needs to be done, they are also a list of what has not been done to ensure the safety and health of the people and ʻaina of Puna: there has been no adequate health studies, no adequate monitoring of emissions, no adequate testing of drinking and near-ocean water, no testing for contamination, and poor public communication and alerts. The sad truth is that this has not been done for 37 years, since the HGP-A, the first geothermal well was completed in 1976. This sad list of what has not been done, leads to the reasonable question: whose kuleana is it to ensure the health and safety of the people and ʻaina of Puna and why haven't they done these basic things that a diverse group from our community can all agree on? The answer lies in the history of geothermal development in Puna. The State of Hawaii should be protecting the ʻaina and the people, instead, they are the ones who brought HGP-A to Puna. They are the ones who said that open venting the steam was safe, though it contained heavy metals and H2S. They are the ones who closed the project, but did not seal the well and covered over the unlined ponds that were full of the brine. The state has not only failed their kuleana to protect the people and ʻaina, they have been the instigator and benefactor of this poorly-regulated industry. To give you a recent example, just last year a Lisa Young, an Environmental Health Specialist with the Hawaii Department of Health, said the one monitor they have for H2S at PGV was adequate, though she admitted it may not pick up a release depending on which way the wind was blowing. The other entity that has a kuleana to protect the people and the ʻaina is the County of Hawaii. What has the county been doing for 37 years? It seems like a good thing that the county commissioned this study to see what needs to be done. But again it helps to remember history. Last year the Hawaii County Council passed two bills regarding geothermal power. The mayor vetoed both bills, saying there were already funds available for health studies. Shortly thereafter, in August of last year, Puna Pono Alliance made a proposal to Hawaii County to do a long overdue health study. It was only then that the Mayor commissioned Peter Adler to conduct this study of what studies need to be done, paying $50,000 from County coffers to make it happen. This act effectively pushed the discussion about health studies and the ongoing issues with geothermal power until after the closely contested mayoral election. Now, one year after Puno Pono Alliance made a proposal for a health study we have the results of the Mayor's

diversion: it turns out we need a health study. My request to the mayor and to the county is please do not wait another year to do what the county should have been doing for the past 37 years. It is also reasonable to ask, why has the county and the state not protected the people and the ʻaina and why haven't they responded to the pleas of those that live near the plants. The answer lies in the simple fact that both the state and the county have received millions of dollars in geothermal royalties over the decades. They are benefiting from the profits, along with corporations, while ignoring the health impacts and other externalities of geothermal power. In conclusion, I congratulate the study group members for the fine work that you've done. This study is a rallying call for all those who want the state and the county to live up to their kuleana to protect the people and the ʻaina of Hawaii. Mahalo for your work. For your reference, I've included below a copy of a Tribune-Herald article about Puno Pono Alliance's request for a health study. Group seeks $200K for geothermal health study By TOM CALLIS Tribune-Herald staff writer Puna may get its geothermal health study anyway. A group called the Puna Pono Alliance is seeking $200,000 from the county's geothermal asset fund to study potential health impacts of Puna Geothermal Venture. But it's more than just an idea. The group, made up of nearby residents to PGV, already have a study outline and formal proposal in hand, prepared by Neuro-Test Inc. of California. The proposal, which a group member said was submitted to the county last week, may give new life to efforts to study the impacts, if any, of the nearly 20-year-old plant on the surrounding community. The County Council on Wednesday voted against overriding mayoral vetoes of two geothermal bills, one allowing the Geothermal Relocation an Community Benefits Program to be used for health studies and additional air monitoring. Any use of the asset fund, created to to mitigate impacts from PGV, would have to be approved by the Windward Planning Commission. PGV pays about $50,000 into the fund each year. It now has about $2.1 million and has never been used. On Thursday, County Council Chairman Dominic Yagong, who introduced the two bills, submitted a letter to Windward Planning Commission Director Zendo Kern requesting clarification on the process for approving such a request. Kern said in a phone interview that he was unclear on the process since it has never been addressed. The soonest it could be discussed is the commission's next meeting Sept. 6. Agenda items are established by the county Planning Department, he said. Planning Director Bobby Jean Leithead-Todd said she hadn't seen the proposal but added that any county-funded study may have to go through a procurement process. "We would have to review the procurement code," she said. This isn't the first time the asset fund has been brought up during the geothermal debate. Some critics of Yagong's attempt to partially repurpose the relocation and

community benefits fund, covered by geothermal royalties, said they thought the asset fund would be better used for health studies and would not require new legislation. Those critics included the administration. Yagong said he preferred the other fund be used since projects would be overseen by the Civil Defense and not the Planning Commission. But he said Thursday his focus is on getting the studies done. "The public doesn't care which fund it comes out of," he said. The group's proposal involves testing 300 people, including 210 who live near the plant, and 90 "unexposed comparison subjects" from Hilo and other communities. They would be tested for symptoms of exposure to toxins, including loss of balance, hearing and psychological impairments. Paul Kuykendall, a member of the group, said the goal is to see if there is any environmental cause for health problems of people living near the plant. Several nearby residents have testified to the council that they suffer from respiratory or other illnesses that they suspect could be caused by hydrogen sulfide emissions from PGV. The plant says it has a closed system, meaning it doesn't emit gas unless there is a leak. PGV has had six air emission violations but none of the emissions were considered high enough to be a public health risk. The largest single emission was in 2005, when air monitors detected 0.789 parts per million of hydrogen sulfide. It takes 50 parts per million for the gas to act as a "respiratory irritant," according to the state Department of Health. The agency has done two studies, both limited to air quality, that also found no health risks from the plant. Still, some residents are concerned and Kuykendall said he hopes the study would provide some answers. "It seems that everybody, people are every side of the issue, say we need to find out what's really going on," he said. The proposal doesn't make mention of vog from Kilauea, which includes toxins. Kuykendall said the control group would likely take into account background levels, including those contributed by volcanic activity. Yagong said he also plans to submit a proposal for air monitoring funding to the Planning Commission. PGV has three air monitors around the edge of its property and the DOH has one in the vicinity. The DOH used to have three near the plant, but two were removed in the last few years due to funding constraints, said Lisa Young, an environmental health specialist with the agency. Young said the focus has been on monitoring vog which directed funds away from PGV monitoring. She said current monitors are considered sufficient though wind direction may determine whether the one operated by the DOH signals a leak. Asked if it would it make sense to have more, Young said, "Not for just one source. They have three monitors on the perimeter. They are in compliance with their permit." Kuykendall said the DOH wasn't asked to do the study because the group isn't convinced the agency would be entirely objective. Young said she couldn't respond to that comment. She said she isn't aware of any

	discussion at the agency on increasing monitoring or conducting any new studies. “I have a feeling that might change,” Young said.

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Comment/Question:	General comments: Mahalo for making appropriate recommendations regarding the need for health studies and better monitoring. Definitions of “Health” and determining “impacts” Given that this study report is defined as a “public health assessment”, there should be an initial discussion of the definition of “health”. What does it mean to have “health”? Is is simply an absence of diagnosable or treatable disease? How does this public health assessment match with the World Health Organization definition: “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” This is particularly relevant when considering the definitions set out in the permitting of geothermal operations wherein “..The proposed geothermal development activities would not have unreasonable adverse health, environmental, or socio-economic effects on residents or the surrounding property” (Rule 11-8) How one defines “health” in this context determines whether the needs and rights of community members to live peacefully without negative impacts on their well-being are ensured. To this end, the recommended studies should include characterization of the IMPACTS on neighboring communities that go beyond specifically medically diagnosable disease and that include the general definition of “dis-ease”. Only then can a full assessment of the true costs and benefits of geothermal development be made. For example, in specifying “anxiety disorders” (Line 13, Page 46), in the Recommended Health Study A, it is inferred that only psychological conditions that meet DSM-IV definitions are relevant to the health and well-being of residents. It is important to acknowledge that detrimental effects can occur without necessarily resulting in diagnosable mental or physical illness. The recommended health study should include the impacts of noise and stress on residents due to geothermal operations. In addition, when the report talks about "anxiety disorders" in the context of noise, what about ANNOYANCE ? CoH did a fairly comprehensive report about geothermal noise and annoyance some

	years back and apparently has never implemented or enforced anything to address the issue (the report should be included in the references). The way this report addresses the noise issue makes it hard to see COH taking any useful action but this is a real problem that is only going to get worse as PGV expands and other players move in. For neighbors, this is one of the big ongoing problems (along with H2O/catchment contamination and potential emergency situations). This report needs to be much stronger in addressing the problem. In the discussion about noise from geothermal operations, it should be included that noise regulations that specify measurement in dBA are "A-weighted" to exclude low (below-audible) frequencies, however noise from geothermal operations and drilling does include low frequency vibrations. The need for a comprehensive cultural impact assessment There should also be a comprehensive study and assessment of the psychological and other impacts of geothermal operations on native Hawaiian and other belief systems and religious freedoms. The need for a comprehensive baseline studies With regards to any future proposed geothermal development, BASELINE STUDIES of the environmental noise and groundwater quality should be required prior to any permitting arrangements. Prior to Act 97, there were rules for county permit application and amendments that address a requirement for description of impacts to public health and safety. The County of Hawai'i should enact local requirements for those baseline studies along with descriptions of impacts and there should be a priority to ensuring that the subsequent operations comply with those descriptions. The community needs to be protected from situations where negative impacts increase and they are left without recourse. The local government provided by the County of Hawai'i is the appropriate level to ensure that the needs of the community are not overlooked by State priorities and State law allows for this. Seeking, Vetting, and Selecting Researchers In discussion about RFP committee the report talks about "...unbiased local citizens...". While on the surface looks reasonable but does this mean that NO community members who care about their community can be involved at that level. Who decides? What constitutes "bias"? Specific Comments about the report contents: Line 23 Page 5 dBA needs a better definition. A-weighted decibels, abbreviated dBA, or dBa, or dB(a), are an expression of the relative loudness of sounds in air as perceived by the human ear. In the A-weighted system, the decibel values of sounds at low frequencies are reduced, compared with unweighted decibels, in which no correction is made for audio frequency. This correction is made because the human ear is less sensitive at low audio frequencies, especially below 1000 Hz, than at high audio frequencies. Low frequencies are effectively excluded from this measurement Line 9 Page 6 Pentane needs a better definition. Pentane is used as a working

	fluid in the heat exchanger for a binary geothermal process. Line 28 Page 11 "...disposition of geothermal fluids, which may contain toxic materials ... " : Although the report refers to "metals like..." There is no listing of the actual constituents of the brine. This report needs to list actual composition of brine in the report and reference their toxicities. Data from PGV independent testing should be included in the report. Line 8 Page 12 Community members requested a health study funded by the geothermal asset fund via the county council. Mayor Kenoi vetoed that request. Line 40 Page 24 dB should read dBA Line 33 Page 14 "...geothermal policy...no collective position on debate...": This report needs to emphasize that public and regulatory policy must include health and safety for residents and environment. It is not adequate to simply say: "...there must be useful and more definitive health studies. " Line 1 Page 25 HDoH allows up to 70dBA day and night in lands zoned "agricultural" Line 5 Page 25 Hawai'i Department of Health Administrative Rules - Title 11, Chapter 46 Community Noise Control allows for more strict regulation of noise in §11-46-13: The council of any county may adopt and provide for the enforcement of ordinances regulating any matter relating to excessive noise. No ordinance shall be held invalid on the ground that it covers any subject or rule of the State; provided that in any case of conflict between the statute or rule and ordinance, the law which affords the most protection to the public shall apply. Line 24 Page 25 The report concluded that "...geothermal direct use in the Kapoho / Pohoiki area is presently marginally feasible at best." Line 118 Page 52 While better monitoring is essential, it is not appropriate here to be explicitly defining 40m towers. The definition of the monitoring system should be made by experts. Line 12 Page 56 It does not seem appropriate to be explicitly identify persons on the selection committee given that earlier in the report (Section 4, page 14) it is stated that "Naming particular scientists is 3 beyond the mandate of this Study Group"

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Comment/Question:	August 15, 2013 Comments on the Adler Report The Puna Community voice must be given a heavier weight throughout the process, as the County and State agencies involved have been remiss in their

	obligations to the public. Dr. Kilburn should be the scientist to conduct the H2S studies. The Legator Study should be mentioned. The Puna community has been used as unwitting guinea pigs throughout the current geothermal development. Baseline studies of air quality, groundwater, soil contamination and health should be done before any serious consideration of future geothermal development. List of possible affected communities should be expanded to include Hawaiian Paradise Park in light of Mililani Trask's recent comments to Office of Hawaiian Affairs Board of Trustees where she mentions IDG developing the geothermal the resource at Makuÿu. Since the State and Federal agencies whose duties it is to safeguard public health are generally staffed with former or future members from the businesses they are supposed to be regulating, they cannot be trusted to provide unbiased information. Therefore, people from impacted communities should have more room at the table in order to compensate for this defect. The report does not describe in detail what a worst case scenario might look like, and how woefully inadequate are the plans now in place to deal with this possibility. The most fundamental laws of the universe seem to be Murphy's Law and the Peter Principle, so these should be foremost in the minds of people at all times. The trade winds are diminishing, and this needs to be factored in. In addition, there appears to be increased seismicity since geothermal started here. Vicki Vierra Keaÿau, Hawaii

Pahoa Community Center 3:30PM

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1. I commend the members of the study group for all their hard volunteer work and good faith efforts in preparing the assessment. I support the findings and recommendations in the assessment but with some additions.

2. I also support the points raised about the assessment by members of Puna Pono Alliance in an email sent out by the group yesterday.

3. A main point I want to speak to is that despite good faith efforts, we sometimes lose sight of the forest for the trees. More than 20 years ago in the struggle to save the Wao Kele O Puna rainforest from destruction by 500 MW of geothermal planned for that area, a very important video was put together by the Pele Defense Fund entitled "Pele's Appeal." I know that many of you in the study group have seen this video. Besides the importance of saving the forest, the video raises profound questions. What are the psychological health impacts to Native Hawaiian practitioners of geothermal drilling into the Hawaiian deity – Pele? Everyone in this room knows that Pele is the Hawaiian goddess of fire, the goddess of the Volcano. How does geothermal drilling into Pele affect the health of an entire race of people when their spiritual beliefs are not respected, but in fact, desecrated by geothermal drilling into Pele. In the Geothermal Public Health Assessment p. 33 Section 4 General Findings. It states the sole focus of the assessment is "what health stressors have been created by geothermal?" Well, the psychological health effects of geothermal drilling on native Hawaiians religious belief in Pele as a deity was grossly overlooked.

4. I note that no Native Hawaiians, especially Pele Practitioners, were on the Study group. Dr. Maile Tuali'i, PhD from Honolulu was suppose to be a member on the study group but had to withdraw leaving no one to represent a native Hawaiian cultural and religious perspective. Surely, there were others that could have been invited: Palikapu Dedman of the Pele Defense Fund, Dr. Emmett Aluli, UH Dept. of Hawaiian Studies, many of Puna's Hawaiian Cultural practitioners, etc.

5. My main recommendation is this: Include as a separate recommended action on page 8 the need for a comprehensive study of the psychological health effect of geothermal drilling on Native Hawaiian religious belief in Pele as a deity. Put this at the top of the list of your 7 or 8 other recommendations. By putting this at the top of the list of recommendations, you would be showing respect for Hawaii's host people and culture. You would be saying clearly that respect for Native Hawaiian religious beliefs is a top priority and the responsibility of all of us who now call Hawaii home. Also list the video "Pele's Appeal" in the Bibliography resource list.

6. I would further recommend that the study group calls for a complete moratorium on any new geothermal development until all the recommendations called for in this assessment are completed. It's common sense. Before you cause impacts, you

first need to study and understand the possible impacts of the proposed actions. Like the EIS process. You study first to eliminate or minimize the impacts. Otherwise the cart's before the horse. The geothermal cart has been before the horse for over 30 years. Put a stop to that. Call for a halt to any new geothermal before your recommendations are completed.

Mahalo.

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Comment/Question:	Aug 15, 2013 I have lived in Leilani Estates for almost 20 years. I have several health issues relating to geothermal. There are a few points I would like to mention: 1. Dr. Kilburn is an independent scientific researcher who is a world expert on H2S. He was chosen by the community. 2. The absence of the mention of the "Legator study" 3. The absence of the outrage of the Native Hawaiian Pele Practitioners. 4. The absence of baseline studies being required for future geothermal development 5. The absence of a workable and tested evacuation plan 6. The impacted community should have a stronger and louder voice in the selection and recommendations of the study for the county's approval The county does not seem to care about the health and well-being of its community. As an example where is our council person, Greggor Illigan today?

Michael Kelly: **Why a Stinky Geothermal Gas is an Emotional Issue**

It is currently within the DOH Director's discretion to impose more appropriate permit conditions to further limit air pollutants and operations affecting air quality standards on a case-by-case basis. In this regard, over two decades have elapsed since DOH responded to the Hawaii Supreme Court order for the Hawaii DOH to promulgate standards on geothermal hydrogen sulfide (H2S) emissions and regulate these gas levels through the permit process. In addition, the science of H2S physiology and toxicology has advanced considerably over the last two

decades, but no further changes in two decades have made by DOH concerning standards and regulations on H2S emissions. This improved scientific knowledge makes it easy to assert that the current 25-PPB average/hour standard is grossly insufficient for adequately protecting the public health during planned and accidental H2S releases by the PGV plant. As such, the DOH Director should be requested to immediately convene a panel of experts to review the available scientific evidence with intent to revise those standards. In particular, the DOH needs a new standard that is a far shorter interval than a one-hour average. To this end, an adequate system of down-wind monitoring is needed for reliably detecting peak levels of H2S in the lower end of the toxic range.

The American Conference of Governmental Industrial Hygienists (ACGIH), a broadly recognized authority on the health effects of toxic gases, has recently changed its recommended threshold limit values (TLVs) for airborne hydrogen sulfide (H2S) exposure. One ACGIH recommendation for limits on airborne H2S exposure is a STEL of 5 ppm (15-minute short-term exposure limit). http://ohsonline.com/articles/2011/09/01/monitoring-h2s-to-meet-new-exposure-standards.aspx. This revised standard by ACGIH for a STEL of 5 ppm is at the bottom end of the very steep toxicology curve for humans, at a point where H2S definitely has an unpleasant odor (Guidotti, 2010; http://ijt.sagepub.com/content/29/6/569.short). The nasty smell of H2S gas is probably more than just a nuisance at this lower concentration. H2S exposure at this level may have, within minutes, some properties that influence human emotions in other, more maladaptive ways.

It is at the above pivotal point in concentration that human toxicology experiments can be done with short-term exposures to H2S within controlled laboratory settings. For example, a study by Fiedler et al. (2008; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2199294) showed that anxiety symptoms in healthy, highly educated, humans were significantly ($P < .0001$) greater within 10-min after exposure to 5.0 ppm compared to 0.05 ppm of H2S. This result is consistent with an earlier experimental finding showing that an unpleasant H2S odor significantly enhances the emotional startle-reflex amplitude in humans (Miltner et al., 2007; http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8986.1994.tb01030.x/abstract). In combat veterans with PTSD, exposure to lower (smelly) levels of H2S for 60 seconds enhanced PTSD symptoms (plus emotional and distress measures) relative to a neutral odor and also when compared to non-PTSD combat veterans (Vermetten et al, 2007, Table 2; online at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3236699/pdf/nihms340157.pdf). In summary, H2S at the concentrations where it is smelly, enhances anxiety and

even more dramatically so in those who have one form of anxiety-related disorder.

In the human brain, H2H at concentrations that smell noxious, directly activates the most central anatomical structure for human fear, what is called the amygdala. And like the behavioral data, the amygdala activation by "smelly" levels of H2S is greater for combat PTSD veteran than non-PTSD veterans (see above, Vermetten et al, 2007, Table 4). These results are consistent with other finding on H2S and the amygdala (Zald and Prado, 1997, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC20578/pdf/pq004119.pdf); Walla and Deecke, 2010, http://www.mdpi.com/1424-8220/10/9/8185). At the neurochemical level, H2S-induced anxiety is in part mediated via enhancement of N-methyl-D-aspartate receptor (NMDAR) activity because the effect of H2S can be abolished by a NMDAR antagonist (Barcus et al., 2010, http://www.ncbi.nlm.nih.gov/pubmed/19836379). In addition, H2S at physiological levels, enhances corticotropin releasing factor, another powerful modulator of anxiety (Kimura, 2002, http://www.ncbi.nlm.nih.gov/pubmed/12392053). Hence, the above behavioral effects of H2S on fear are not just subjective or soft but are also seen in neurobiological measures of anxiety.

At the level of health epidemiology, it thus is perhaps not surprising that the draft (V-3, 7-27-2013) version of the Geothermal Public Health Study recommends that in a more comprehensive health study "a priority should be placed on… monitoring for anxiety disorder[s]" (broadly conceived) in individuals exposed to geothermal gases (http://www.accord3.com/pg68.cfm).

August 14, 2013
Peter S. Adler, PhD
ACCORD3.0 Consultants
2471 Manoa Road
Honolulu, Hawaii 96822

Re: Puna Health Study
Dear Dr. Adler:

Please consider these comments with regard to your draft report.

Background

In July of 2012 the Puna Pono Alliance (PPA) submitted a proposal to former County Council Chair Dominic Yagong seeking funding for a study to be led by Dr. Kaye Kilburn of Pasadena, California, to identify the health problems of people exposed to Puna Geothermal Venture (PGV) emissions. (Mr. Yagong had previously introduced a bill to direct geothermal royalty money toward health studies, but the Mayor vetoed the bill. In doing so, the Mayor said the county will conduct a "thorough, open, transparent and community-involved [geothermal health] study....") Mr. Yagong then forwarded PPA's proposal to the Planning Commission to consider funding from the Geothermal Asset Fund.

A geothermal health study should be done, according to Mayor Billy Kenoi's October 2, 2012, News Release that said: "Health issues related to the production of geothermal energy are a concern for many island residents.... County Department of Research and Development has contracted for an independent joint fact finding study to help lay the groundwork for future geothermal health studies to be conducted in the Puna community." Your contract to plan future Puna geothermal health studies resulted from actions by PPA, the County Council and Mayor on the same subject.

On February 9th Dr. Kilburn addressed the Puna community about health issues at the Akebono Theater in Pahoa. On February 10th Dr. Kilburn attended the second in a series of your study group's meetings. At that meeting the group heard from Dr. Kilburn and other physicians about their experiences and observations treating patients with health issues they believe may be linked to geothermal energy production – including teleconferences with Dr. Janette Sherman and Dr. Sam Ruben. Dr. Ruben was the Department of Health's District Health Officer in Hilo during previous PGV incidents. Dr. Sherman and Dr. Ruben both referred the group to rely on Dr. Kilburn when asked how to best approach a health study, and Dr. Kilburn answered a number of questions from the group about health study matters.

Kilburn/Travis Sampling

After Dr. Kilburn's visit, he left equipment and supplies allowing Laura and Tom Travis to conduct a small sampling survey to look for measurable neurological impacts – the primary harm caused by hydrogen sulfide (H2S) – in lower Puna. The March and April sampling was expected to refine the health study proposal Dr. Kilburn previously submitted. For example, if negligible results were obtained from the sample then that would indicate the need for a more sensitive and wider epidemiological approach. The results of the sampling were surprising: the people from Puna showed statistically significant neurological impacts, and the people in Hilo also showed statistically significant neurological impacts. The survey used eight tests from the extensive battery of neurological and pulmonary measurements employed by Dr. Kilburn in his method for such studies. The

measurements were delivered to Dr. Kilburn in Pasadena, California, for evaluation by Neuro-Test (his medical research company) assisted by computer analysis from an Oregon firm. Dr. Kilburn has used his extensive test regime in numerous community health surveys and with it he also has developed similar data for a non-impacted control group from Tennessee. Included in the testing was a three page symptom frequency assessment, where patients self-reported the frequency of their physical symptoms using a standardized rating system of 35 complaints including indexes of irritation, respiratory, cardiac, sleep, memory, headache, concentration, dizziness and gastrointestinal complaints – the results of the assessment showed greater differences in the Puna group. The results of the assessment also were consistent with the results obtained by Dr. Marvin Legator's assessment more than a decade earlier.

Dr. Marvin Legator

I worked with Dr. Legator during his study and I witnessed first hand how the State and PGV took extraordinary efforts to undermine and demonize his competent work. If you read his report you would see a careful and reasoned analysis of the medical symptoms reported by Puna residents, in combination with reports from residents of another town impacted by H2S, and all compared with a control group. Two currents converged in reaction to Dr. Legator's work: (1) the scripted theme of the pro-geothermal dialogue to the effect that while we once had problems they are gone now and (2) the staged view that Dr. Legator's study was somehow incompetent and undeserving of any respect. The latter view is a manufactured piece of propaganda, a result aggressively sought by DOH and PGV, as was reported by Jim Morris in a Houston Chronicle article titled *Poison in Paradise* (11/09/1997), quoted in part below: Two of Legator's research associates went on a scouting expedition to the Puna District in March 1996, conducting interviews with 69 people. Legator made his first visit at the beginning of this year and announced his preliminary findings – symptoms [1] *See also* page 35, lines 27-41, for similar content consistent with hydrogen sulfide exposure – at a Jan. 9 news conference at the University of Hawaii at Hilo. Legator thought he had made it clear that more work needed to be done. He realized that something was seriously amiss, however, when he read an article in the Jan 12 edition of the Hawaii Tribune-Herald.

The headline was, "Official: Health Survey Bogus." The story quoted Bruce Anderson, deputy director of the state Department of Health in Honolulu, as saying that the results of any survey Legator conducted would be inherently biased because the subjects were rabidly anti-geothermal and had had years to bone up on the effects of hydrogen sulfide. The attacks didn't stop there. On March 26, a PGV official appealed to William Cunningham, chancellor of the University of Texas System in Austin. "PGV is surprised and disappointed that

the University of Texas would knowingly allow its fine name to be attached to a health survey of the type produced by Dr. Legator," wrote Jack Dean, the venture's vice president and general manager.

Draft Report Omission

On page 8 of your report, at lines 13-20,[1] the Legator phenomenon appears: After 1993, the Study Group is uncertain about whether there have been health effects and what the extent and severity of those effects are, if any, due in part to poor identification and documentation in health studies. No study has clearly identified the scope of the effects nor has any study established clear causation. Since 1991, no health study has identified any health effects that can be attributed to geothermal development or operations, but monitoring of exposures has been inadequate.

The only way to be uncertain about health effects after 1993 is to ignore Legator's report (published in 2001 based on work done in 1996 and 1997.) Dr. Legator's health "identified a variety of adverse health symptoms that appear to be associated with chronic exposure to low levels of H2S." H2S can be attributed to geothermal development or operations. In fact, what other source of H2S could have caused the identified health symptoms? Furthermore, the report says Dr. Legator relied on "several objective neuropsychologic tests and measurements that were performed on subjects in the exposed Puna and the reference Hilo communities. The results of these tests support findings within the important CNS symptom category." Thus, Dr. Legator's study carefully catalogs statistical results of symptoms by category and further substantiated the CNS symptom category with neuropsychologic tests and measurements. Dr. Legator's results also were supported by the results of Dr. Kilburn's three page symptom frequency assessment administered this year by Laura Travis (and their neurological testing results.)

Dr. Legator's work was intentionally attacked by state and PGV officials to detract from its reference value as evidence of on-going health effects from H2S. PGV is the source of H2S in the studied community. Dr. Legator "identified health effects that can be attributed to H2S" (*ergo*, attributed to geothermal development or operations.) His work is overlooked, ignored or otherwise unknown in the draft report in part because of a theme that says former problems from PGV have been resolved, and in part because of the residue from the attacks on Dr. Legator that had the desired effect of suggesting his work was incompetent, and in main part because the most significant propaganda point in the pro-geothermal argument is that health impacts from chronic low level exposure to H2S are unknown. Dr. Legator's report says that "our results, providing evidence of the elevated prevalence of adverse health symptoms in communities potentially exposed to low levels of H25, emphasize the need for

further studies on the effects of this toxin. ... we anticipate that studies such as this one will play an ever-increasing role in identifying potential health problems related to chronic exposures to toxic substances." He was competently addressing a fundamental issue in geothermal health and safety. His work merits a much greater degree of respect than is shown in your draft report.

Another Omission

Also omitted from the draft Report is a study published in *Society and Natural Resources*, Vol. 8, February, 1995, by Michael R. Edelstein and Deborah A. Kleese titled *Cultural Relativity of Impact Assessment: Native Hawaiian Opposition to Geothermal Energy Development*. Dr. Edelstein is a Professor of Psychology in Environmental and Graduate Sustainability Studies at Ramapo College of New Jersey. The study "proposes that the conflict over geothermal energy development represents two belief systems holding opposing views of the environment. Western attitudes toward nature regard the environment as a series of natural resources to be managed. In contrast, Native Hawaiian beliefs regard nature as sacred. Specifically, geothermal energy development threatens perhaps the most sacred space in all Hawai'i, the home and body of the fire goddess Pele. The lengthy administrative proceedings in this matter are instructive of the marginalization of native peoples and their difficulty in gaining recognition for cultural impacts in a decision-making process that is built around the rationality of the dominant Western world view." Dr. Edelstein has expressed an interest in conducting a follow-up study as part of the health review of PGV impacts. Psychological health is a relevant factor. One of the points made by Dr. Edelstein concerns the common psychological problem of a community impacted by toxic emissions being blamed for having the impacts. Another part of the problem is the value of native wisdom that is being marginalized and disregarded in considering geothermal issues. Having lived with the volcano and its special environment for many generations, Hawaiian wisdom recognizes aspects that are overlooked by more recent students approaching the situation with devices made to measure specific quantities. Some qualities of the volcanic environment are not measurable in the context of modern science. The 1995 study reflects upon spiritual qualities of the volcanic environment: Some interpretations suggest that Hawaiian gods and goddesses were mortal in the sense that, if the natural phenomena that personified them changed, they might die. Pele's special importance to many Native Hawaiians may rest on the belief that she alone has survived the intrusion of outsiders. Her survival perhaps reflects the fact that she was tied to a specific place that continues to reveal her manifestations. A fundamental problem is the loss of places with special meaning, places that have been memorialized in chants and held in respect, but are now less accessible or altogether removed. A cultural tradition that thrives on ancestral connections needs a continuing sense of presence, such as is found in a special place. The dominant world view, as

described by the study, does not rely on ancestral connections or sacred places, but exploits the environment for profit and advantage. That approach can have unhealthy results, as was well known to native wisdom and is still being realized by efforts such as the health study studied by your group. If actual health is a goal then part of that end is respect for nature and its sacred aspects, and the culture of people living their lives form that point of view.

Base Line Studies

It is too late to do a legitimate base line study for neighbors of PGV (a neighborhood that could be a quite expansive in terms of distance.) The existing impacts from HGP-A and PGV put any thought of measuring an untouched base out of reach. A status quo study is conceivable, but if by correctly assuming there are cumulative impacts from past incidents and those impacts are aggravated by each new incident, the question of what is being measured becomes relevant. The answer to the question is probably the same answer to this question: what would a health study of geothermal impacts show? In other words, for HGP-A and PGV related matters, the health study is the base line study for future development.

Meta-Analysis

I regret the fact that a meta-analysis of H2S literature will probably be a waste of time. It is so, however, in the same sense that analysis of literature on immigration issues would be of less than scientific value. H2S issues are no less contentious than other political issues and the scientific literature reporting H2S studies is biased by the situation of respective authors. As an illustrative point, perhaps you have heard or read about instances of pro-geothermal advocates in Hawai`i quoting the first report from Dr. Bates as saying his study shows H2S is good for your health. That is a mis-representation of what Dr. Bates actually said, but what Dr. Bates actually said was written in such a manner that it could be mis-quoted by pro-geothermal advocates.

If you want a further illustration of the strong lobbying arms that support disregard of the perils associated with chronic exposure to H2S, please take a look at industry positions on H2S and efforts to refute them as described in the recent publication by the federal Environmental Protection Agency (EPA), titled *Hydrogen Sulfide; Community Right-to-Know Toxic Chemical Release Reporting*, starting at page 64022 of the Federal Register, Volume 76, No. 200, Monday, October 17, 2011. It says that the "EPA has determined that hydrogen sulfide can reasonably be anticipated to cause serious or irreversible chronic human health effects at relatively low doses and thus is considered to have moderately high to high chronic toxicity.... Hydrogen sulfide has also been determined to cause ecotoxicity at relatively low concentrations, and thus is considered to have high ecotoxicity." The main substance of the publication is an extensive chronicle of

how the H2S emitting industrial lobby succeeded in delaying for eighteen years the publication that was ultimately accomplished in 2011 – *after it was first proposed by the EPA in 1993.*

Resistance to recognizing the health problems associated with H2S is entrenched and extends far beyond geothermal into a multitude of industries that would be economically impacted by such a recognition – and the resulting remedial needs.I further regret the need to suggest that the very existence of your contract resulted from the same political motivation. Dr. Kilburn, like Dr. Legator, is recognized by the H2s industry as an adversary unfailingly dedicated to reporting actual harm his patients have suffered from H2S exposures that industry lobbyists say should not be recognized. Based on my experience with Dr. Legator's work in Puna, I have no doubt part of the idea of funding your study was to distract attention from the growing public demand for a legitimate health study and specifically from the proposal submitted by Dr. Kilburn. My feelings in that regard are supported by this statement on page 14 (lines 3-4) of the draft: "naming particular scientists is beyond the mandate of this Study Group." I have carefully reviewed your contract with the County and I cannot find anything that supports such a statement therein. My feeling is that an unstated premise of your agreement to do the County's bidding was to keep Dr. Kilburn's proposal at a distance from the results. If that is insulting to you because it is untrue, then I apologize in advance. Nonetheless, it is a serious insult to the health of the community to have completely excluded Dr. Kilburn's proposal from the study report.

Conclusion

Introducing the issues, on page 29, the draft refers to framing the inquiry on questions that began, at lines 21-22, "what evidence is there of possible negative health effects linked to geothermal energy production?" I was only able to attend one meeting in person, the second meeting when Dr. Kilburn was present, but I remember the discussion in the meeting addressing that question of evidence of harm and a threshold consensus emerging that the evidence was sufficient for the group to stipulate to such harm and go on from there. Having obtained such a consensus stipulation that the group found sufficient evidence of possible negative health effects linked to geothermal energy production, that premise should be at the foundation of the report. What is of some concern is the fact that the stipulation obtained early in the group process seems to be less present toward the end. Here, again, I will reiterate the concern expressed above about the phenomenon that was spun off of Dr. Legator's work, and seems to be spinning on to Dr. Kilburn's proposal, and that was described in such depth by the EPA – that phenomenon is the myth perpetuated by the H2S industries' lobbies, lawyers and public relations regarding an absence of harm from low level H2S exposure, and relentless efforts to demonize any effort to contradict the myth. You are in the

midst of that phenomenon now, and I hope you succeed in navigating those waters well.

These comments only touch highlights of matters of my most immediate concern. Many additional matters are related to the health study, such as the woeful state of monitoring and the disregard of competent emergency response planning that are prime examples of government neglect of real and serious geothermal problems. Those issues deserve attention, but it is the primary purpose of your group, evidenced by your contract, to address "the long term health of the neighboring communities that surround geothermal energy development on Hawaii Island." Therefore, the first priority in your report's recommendation should be the need for a competent health study. There is every good reason why your recommendation should be that Dr. Kilburn's proposal should be accepted.

Aloha,
Bill Smith
P.O. Box 1211
Volcano, HI 96785

PS I hope you can find a way to re-phrase this statement on page 16, lines 6-7: "Workers must be protected through regulation and by their owners and managers." Doesn't that kind of reduce the sense of being a worker to something like an owned commodity?

From Michael Kelley:

The smell of H2S gas is not just a nuisance but is probably dangerous

Another approach to H2S toxicology from industrial geothermal gases can be to look at the effects of H2S on cultured cells. This is a useful lab procedure for scientists looking at H2S as a gasotransmitter in neurophysiology. While low and physiological levels of endogenous H2S within the body protect neurons, adding exogenous H2S shows immediate neurotoxicity at just higher concentrations. This is important because of the very steep dose curve for H2S toxicology. In part, H2S-induced neurotoxicity is mediated via enhancement of N-methyl-D-aspartate receptor (NMDAR) activity because toxicity of H2S can be abolished by a NMDAR antagonist. The physiological levels of H2S in the human, rat, and bovine brain are relatively high, ranging from 50 to 160 millimoles [millimolar is a concentration expressed as 10^{-3} of a mole per

liter]. Within this physiological range as a gasotransmitter, H2S exerts multiple effects at physiological concentrations in the brain. For example, it potentiates the activity of NMDARs and enhances long-term potentiation in the hippocampus associated with learning and memory. However, just slightly increasing H2S levels disrupt the ionic homeostasis in the cortex. These effects are dose dependent and seen within several minutes *in vitro*. Thus, whereas H2S in physiological concentrations exerts a minor effect on ionic homeostasis as a gasotransmitter, at super-physiological levels it can be neurotoxic as it can disrupt the ionic homeostasis by markedly increasing Na ion influx through its action on ionotropic glutamate receptor channels. A large alteration in extracellular/intracellular Na ionic concentrations may trigger an event that leads to neuronal injury and death. These effects begin to be seen at just above physiological levels of H2S. This bears upon the issue of what dose and duration of exposure to geothermal H2S is neurotoxic, even if gross effects on symptoms are not conspicuous.

Not being an expert in molecular physiology with *in vitro* procedures, I have summarized this emerging evidence as best I can from a recent report in,

Toxicological Sciences, **128**(1), 198–208 (2012)

Hydrogen Sulfide Induced Disruption of Na+ Homeostasis in the Cortex

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Abstract:

Maintenance of ionic balance is essential for neuronal functioning. Hydrogen sulfide (H2S), a known toxic environmental gaseous pollutant, has been recently recognized as a gasotransmitter involved in numerous biological processes and is believed to play an important role in the neural activities under both physiological and pathological conditions. However, it is unclear if it plays any role in maintenance of ionic homeostasis in the brain under physiological/ pathophysiological conditions. Here, we report by directly measuring Na+ activity using Na+ selective electrodes in mouse cortical slices that H2S donor sodium hydrosulfide (NaHS) increase d Na+ influx in a concentration dependent manner. This effect could be partially blocked by either Na+ channel blocker or N-methyl-D-aspartate receptor (NMDAR) blocker alone or almost completely abolished by coapplication of both blockers but not by non-NMDAR blocker. These data suggest that increased H2S in pathophysiological conditions, e.g., hypoxia/ischemia, potentially causes a disruption of ionic homeostasis by massive Na+ influx through Na+ channelsand NMDARs, thus injuring neural functions. Activation of delta opioid receptors (DOR), which reduces Na1 currents/influx in normoxia, had no effect on H2S-induced Na1 influx, suggesting that H2S-induced disruption of Na+ homeostasis is resistant to DOR regulation and may play a major role in neuronal injury in pathophysiological conditions, e.g., hypoxia/ischemia.

First Name:	Dave
Last Name:	Kisor
Email Address:	panther_dave@yahoo.com
Comment/Question:	I don't know why, but I couldn't say what wanted to say, while some of this came to me after the public session. My life has never happened according to schedule. There's too much money at stake and that's all some ever consider. I see enough money involved to fill a very large sewage treatment facility, but all Puna will get out of this deal will be an enormous quantity of the initial input of said sewage treatment plant. People have been incarcerated for not having any money, but I don't know of any cases where money has ever been charged with not having enough people. I understand Billy Kenoi is considering a run for US Senator, which will require more money than Mayor, so he may have to veto the health study, no matter what Peter Adler

	recommends. He is after all, a politician and the true definition of politics is poli = many, tics = blood sucking creatures (authorship anonymous). If he supports the health study, he'll shoot himself in the political foot. As an aside, during a talk story, he bragged how he hitch hiked from Kalapana to Hilo when he attended law school, but I discovered later he signed into law soliciting a ride illegal. Hmmmmmmm! While it isn't usually enforced, it is on the books. We are now at the trailing edge of what has been termed geothermal war two, and a good number of those who survived geothermal war one grew to distrust Peter Adler, whilst some came to absolutely detest him rather vehemently. He is now very much aware the community is watching, so whatever happened before can't be repeated with impunity and he is painfully aware of the major concerns that were gratuitously omitted from the latest report for community scrutiny. Strange though it may appear, I'm trusting Peter Adler to write the report addressing community's concerns, it's Billy Kenoi I question. Whenever there is big money involved, it's invariably the little people who suffer. This is just an opinion based on observations and nothing more.

Indigenous Consultants, LLC

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Aloha Peter,

I am forwarding these comments to you & your advisory committee re: the Draft V-3 Report of July 27th, 2013. Please forward any response directly to my email, Mahalo for your work on this matter.

Aloha,

Mililani

General Comments on Report & Study Group Composition:

1. From the outset, no geothermal development supporters, including folks with technical & health background, were included in the study group because of concerns about their pro-

geothermal bias & conflict of interest. However, many of the study group members who are actively opposed to geothermal development and who have made a lucrative business from opposing geothermal development were allowed to participate. This has negatively impacted the report and resulted in biased data and information in the report.

EXAMPLE: The report indicates that this effort began in September 2012, with a request from the Mayor to Peter Adler for an "independent" joint fact finding Study Group. In fact 7 months earlier, convicted drug grower Bob Petreicci and members of the Puna Pono group as well as several people previously involved in PGV litigation, hereafter the Caucasian litigants, had gone to the County Council demanding funding for money for their Doctor (Kilburn) to do a health study of themselves, for evidence to use in their future litigation to stop geothermal development. The County record is replete with agendas & testimony matter on this for the 7 months preceding the mayors' request but there is no mention of this in the report. The report section on the history & background was doctored in order to make it appear that these events did not occur, but they did.

EXAMPLE: The report falsely states that there were 8 tort cases filed, but it reports only the outcome for 6 cases. There are several other cases involving health & property damage allegedly caused by PGV, but these cases are not included in the report because the outcomes did not favor the positions taken by convicted drug grower Petreicci and the Caucasian litigants. The case of Maureen Gap is illustrative.
Gap v PGV was filed by Maureen Gap in 1995, & decided in 2002 with sanctions against Gap. (See N. 25210, Dec. 16, 2004). Gap alleged that PGV was responsible for her increasingly acute asthma. She had listed 5 Expert Witness who would prove her case at trial, with the primary issue being Causation: proof that the PGV plant caused her medical condition. She has intended to rely on data from Sherman & Legator but was unable to take this evidence to Court when Sherman said she as too busy to attend & Legator responded that his study was not ready for trial. Dr. Ruesing, Gap's treating physician said that she could not testify re: causation was not qualified to do so. Dr. Sword, a psychologist called by Gap testified that causation was beyond the scope of his experts but he opined that Gap suffered from anxiety because of her belief that she lived in a toxic environment. Finally, Dr. Schrader, an allergist who had never treated Gap for asthma, stated …" "…he did not know where Gap was living when she was first diagnosed with asthma and he did not know the distance between her home and the PGV plant; he also did not know whether there were trees or plants on Gap's property to which she was allergic (which allergies might have caused Gap's respiratory problems and asthma). Dr. Shrader further stated that other factors on the Big Island (such as mold, dust, pollen, mites, vog, or other environmental factors) could play a role in Gap's asthma. When Dr. Shrader was asked directly whether he was able to render an opinion on medical causation to a reasonable degree of medical probability, he responded: "I think it's fair to say that, scientifically, it would be very difficult to draw a conclusion

without being presented with more evidence, statistics, as to the episodes of venting and concentrations of H_2S at the time of [Gap's] episodes."

Gap lost her case 20 months after she filed it because she could not show PGV caused her illness Because Gap had raised allegations against PGV & was not able to provide the medical proof of 'causation', sanctions were appropriate. Sanctions are approved whenever litigation is filed that is unwarranted & unsubstantiated.

EXMPLE: Years ago the State Department of Health reviewed a Health Survey created by members of the group now calling themselves the Puna Pono Alliance. The State concluded that the survey was Bogus because it was deliberately created by the litigants for trial. This historical fact is omitted in the report.
See: Health Survey Bogus, Hawaii Tribune Herald, January 12,1997, by Kevin Dayton.

These are only a few examples of how data in the Study Group report is biased. The Report should correct these omissions & provide real & accurate information about the litigation history & outcomes of all cases filed. The Report should state how much money convicted drug grower Petreicci & others including Saracusa
made off of their unproven claims.

The record of litigation regarding geothermal development in Puna verifies that there is a small group of Caucasian Litigants including convicted drug grower Petreicci who have repeatedly sued PGV raising health allegations, but settled for money rather than prove their case in court & get the plant closed. The record indicates that there has never actually been a single case where causation was shown at trial and proof was offered that linked illness to PGV's plant operation.
The record indicates that there has been a toxic & interdependent relationship between Ormat & convicted drug grower Petreicci and the Caucasian litigants, specifically, they sue and agree to receive money, Ormat pays, gets the tax & business deduction & the amount of money recovered from the litigation is never revealed.

EXAMPLE: The Report cites only 6 cases that were settled and says that these cases were settled for "undisclosed amounts". This is a lie. The case record contains settlement documents that say the amounts were not to be disclosed, however convicted drug grower Petreicci & the Caucasian litigants have disclosed these amounts on their web site and in public hearings. Evidence of this is all over the Internet.
See:http://www.bigislandchronicle.com/2013/04/14/letters-from-mililani-trask-taking-issue-with-the-sierra-club-and-puna-pono-alliance/#comment-238355, you will find convicted drug grower Bob Petreicci blogging about the 2 million dollars they recovered from these cases including his own recovery of "tens of thousands" of dollars.

Other "independent" members of the Study Group have also admitted they received money. See http://www.bigislandchronicle.com/2012/04/20/letters-regarding-health-problems-attributed-to-geothermal-technology/#comment-129964 where Renee Saracusa says … "I was one of the parties to the lawsuit that Bob mentioned, and I received settlement money. Although I am not as close to PGV as others, the blowout caused my young billy goat to die and all the honeybees that were pollinating my tangerine orchard. I lost several years' crops as a result. I also had health effects that were documented when Dr. Kevin Kuwahara examined many of us for DOH. And, Mililani, there was at least one death as a result of the blowout: a young otherwise healthy Hawaiian woman had her fetus blow up inside her uterus! Malama na pua…".

Well, Mililani did follow-up on Saracusa's blog & I found out that the Puna Pono folks have repeatedly use the 'dead Hawaiian child' reference in their testimony but that the Hawaiian family was not "invited" to be part of the Caucasian litigant group because the Caucasian litigants were afraid the Hawaiian would get all the money because she had a dead child & they only had a dead billy goat, and confused honey bees !!!

If the Study Group reviews the tapes from the first Puna public meeting on Geothermal they will find several speakers talking about how money can be made through litigation & settlements. These are on the Internet & the Puna Pono web site, but have been completely omitted in the Report. The conflict of interest forms signed by Study Group members do not contain the actual amounts that these people made off of their litigation settlements with Ormat.

2. The Findings in the Report do not relate to the Recommendations in the Report:

The Report found that 1) Puna's public health profile is unclear (p.34); 2) that the majority of people living in Puna or "84.2% of Puna's population report themselves to be in good health, (p.35); 3) that there were "health effects" from exposures early in the development of geothermal (before 1993), ….but 4) "After1993, the Study Group is uncertain about whether there have been health effects..".

The report found that… "Since 1991, no health study has identified any health effects that can be attributed to geothermal development or operation…".

The Report reviewed …."240 health related testimonies attributing causes to PGV …., most were found to be second-hand reports…" (p.37) .

Despite these findings, the Report concludes (Finding 3, page 39) that "Risks from geothermal energy production in Puna exist..".

The Report thereafter makes numerous recommendations for studies on H2S, Emissions, Noise, Vibrations, a Meta Analysis by USGS and a "scientifically robust study of H2S.

See section V, p. 42 forward.)

3. <u>The Recommendations in the Report do not address problem areas or propose viable solutions.</u>

A. The Report documents that the overwhelming number of complaints focus on noise from the PGV plant. The County has been aware that there are simple technological solutions to noise & that Ormat/PGV has refused to use viable technology to resolve this problem. This solution, which is an obligation of Ormat & not of the County, is ignored because the focus of the Report & its outcomes are not solution based but intended to justify another health study for another case brought by convicted drug grower Petreicci & the Caucasian litigants. The Study Group made an exception to its own rules to allow Ormat to participate in the Study Group, but Ormat would not recommend any solution that would cost them money. The Caucasian Litigants also have no incentive to recommend technical solutions because resolution of these problems would prevent them from personally recovering any further money from "settlements" resulting from unproven claims raised in unwarranted litigation. Hawaiian developers and Indigenous Consultants who have extensive background in "Best Practice's and Tech Solutions" were not allowed to be part of the Study Group because of "bias & conflict of interest".

B. Other solutions were also ignored. For years there has been a solution to toxic venting from flumes & smoke stacks during emergency situations. Best Practices in the Industry require that operators install "scrubbers" to remove any toxic agents from fumes BEFORE venting. This technology costs 3-5 million dollars but it will not be considered or discussed by the Study Group because Ormat doesn't want to pay for this corrective measure and because the goal is not to address health threats but to provide another health study for litigation for convicted drug grower Petreicci & the Caucasian litigants.
C. The Report calls for numerous studies to be undertaken now & in the future, without any documented negative health impact after 1993. The recommendations come from a volunteer group, many of whom are biased against geothermal & are seeking evidence to bolster their claims in future litigation.
D. No data is provided on who will conduct these studies, what their qualifications should be, the length of time & scope of these anticipated studies or the cost for this work. USGS Honolulu, Dept. of Health & JABSOM are all mentioned in the Report but these bodies did not participate in the Report & have not been asked to comment on the Reports recommendations from a scientific perspective. I know because I contacted them for their input & none knew about the report.
E. I have checked the County budget & there is no funding allocated for these reports in either the Administration or Council budget. Geothermal Royalty funds are not available for studies because all funds are held for relocation purposes for convicted drug grower Petreicci & the Caucasian litigants. Where is the cost-benefit analysis for these studies?
F. Past health surveys & studies conducted in Puna were ethnically biased. Puna has

a huge Asian & Hawaiian/Pacific Islander population, but past surveys & reports only considered data from Caucasians. Will future studies address this racist problem? The report makes no recommendation for ethnically balanced follow-up studies, is this because a decision has already been made to avoid the County RFP process when public money is spent?

G. Finally the Report is not based on scientifically gathered data for health purposes. It's a political Report created in an election year by a candidate who had already travelled to Asia to examine, support & endorse Ormat technology. Are scientific research standards going to be followed when these studies are undertaken? The Report does not even address the basic requirements for credible research undertaken by qualified health professionals with a background & capacity to do Health studies.

Before the County Council or the Mayor supports any recommendation from this Report, the issues raised herein should be addressed & misinformation & omissions corrected and addressed. Technical solutions to toxic venting & noise should be included.

PUNA GEOTHERMAL VENTURE
HAWAI'I
an ORMAT company

COMMENTS REGARDING DRAFT HEALTH ASSESSMENT FINDINGS AND RECOMMENDATIONS
15 August 2013

Due to the apparent divergent views which comprise the panel, the draft findings and recommendations contain somewhat speculative comments and observations which should be tempered with clarifications explaining the lack of scientific data to support stated hypotheses. Whether stated as hypotheses, concerns or speculation, care needs to be taken in each instance to make clear that none of the hypotheses have been proven.

The study group helped to identify the issues and should be commended for making recommendations for a scientific and unbiased study. Following, you'll find Puna Geothermal Venture's specific suggestions and additional thoughts for each section of the report.

Thank you for your consideration.

Mahalo,

Mike Kaleikini
Senior Director of Hawaiian Affairs, Puna Geothermal Venture
mkaleikini@ormat.com

Executive Summary

Caution should be exercised at how certain comments or phrases which can be found in this section and elsewhere can be taken out of context for both PGV and in other contexts.

Findings

Page 8, Line 22: First sentence, the word “may” should be used to qualify the statement as to the existence of risks. At the same section and line, the next sentence should read as follows:

“The actual nature, extent, potential and impacts of those risks remain unresolved.”

Recommendations

Page 9, Lines 1-4: The first sentence is an un-responsible statement. Where did this idea that heavy metals may have contaminated the soil originate? Is there any evidence that this may have occurred, and what is the basis for same? Why not clearly state this is an as yet unsupported concern or hypothesis instead and indicate that thus far there is no evidence that such contamination has occurred?

Page 9, Lines 5-8: Providing information or references on existing data on soil samples, and more importantly, water quality sampling which PGV has, or reporting the information that can be appended as comments, would be helpful. Where the statement about those in the vicinity of geothermal “may be more likely to show anxiety disorder symptoms” came from, other than as a speculative statement, is unclear. Any study of this issue would also need to decipher whether any higher incidence of such disorder came about because of actual conditions as opposed to the publicity from the hearings, as well as the variety of other causes which may exist.

Page 9, Lines 33-34: This sentence should be deleted and replaced with “The hypothesis of whether ocean contamination exists and the nature and extent of any such contamination, should also be further studied or assessed.” Again, PGV and the State should have data as to the lack of such contamination, and the conclusions should be identified. Information as to existing data can be published or referenced.

Page 6, Line 9: Pentane is a hydrocarbon used as a **working fluid**, not a “solvent” as stated.

Page 7, Line 11: Stating that “residents must consider the health risks that may be associated with geothermal energy production” can be taken out of context. PGV suggests inserting “residents must consider the health risks that may **or may not** be associated with geothermal energy production.”

Page 8, Lines 22-27: PGV suggests the following edits: “Risks from geothermal energy production in Puna **may** exist. The actual **nature,** extent and **potential** impacts of those risks remains unresolved. What is known is that hazardous chemicals come up and go back down in PGV’s closed system. Some fluids inevitably escape to air, **potentially into the ground**water,

and/or at ground level. **Effects** can **potentially** be **better** understood through monitoring and reliable health data."

Page 9, Lines 38-40: This statement assumes contamination of ocean waters from geothermal activities exists. The lead to this section can more accurately state that "Using robust scientific methodologies, the county can test stated concerns about the possibility that brine could be migrating vertically and causing contamination of ocean waters. However, no evidence currently exists that such is the case, or that coastal and near-shore animal or plant life has been adversely affected." The section can also address the current known contamination of near shore waters with effluent from cesspools and high coliform counts in near shore waters, and indicate that a proper study would also need to analyze or differentiate between impacts of such contamination.

Introduction and Background

Page 10, Section 5: The preparation of requests for proposals should also be conducted or reviewed by disinterested scientists.

Page 11, Lines 17-19: States that "Closed loop plants such as Puna Geothermal Venture ("PGV") located in the Puna District on the Island of Hawai'i are designed to have only incidental emissions." PGV is not designed to have only incidental incidents. PGV is designed to be an entirely closed-loop system. For various reasons incidental incidents have occured.

Page 11, Lines 21-22: The sentence "It is a renewable fuel that has prices competitive with fossil fuels." PGV suggests that this sentence be expanded as follows, "It is a renewable **energy resource** that has prices **currently** competitive with fossil fuels. **Geothermal energy reduces the need for importing and using fossil fuels, which are County and State goals. Reduced use of fossil fuels results in a reduction of greenhouse gases. As the price of oil continues to increase, geothermal energy will be less costly than fossil fuel energy."**

Page 11, Lines 28-30: The term "toxic" is unnecessary, and can be substituted with geothermal brine. Also, the concern can be stated as to "whether geothermal activities can induce seismicity, although there has been no indication that this has yet occurred as a result of PGV's drilling or production activities."

Page 11, Lines 32-34: Referring to geothermal facilities, this sentence states that "They may have positive impacts…" PGV suggests editing this to "**Geothermal facilities provide** positive impacts…"

Page 15, Lines 38-40: This sentence states that people living close by "had no say in its location." This is an incorrect statement. Public hearings were held on all aspects of the permitting process for the PGV facility. This would include the County Planning Commission and Planning Department, State Department of Health (Clean Air Branch and Safe Drinking Water Branch), State Department of Land and Natural Resources, and at the Federal level with the Environmental Protection Agency.

Page 22, Section C. Geothermal Energy development in Puna: PGV would like to clarify and

insert the following sentence on page 23, line no.38 after the sentence ending in “Company, PGV.”, **Between 1989 through 2004, PGV was owned and operated by Constellation Energy, a utility company with corporate offices in Baltimore, Maryland. In June of 2004, PGV was purchased by Ormat Nevada, Inc. Ormat, with corporate offices in Reno, Nevada is the current owner and operator of PGV.**

Setting and Context

Page 24, Lines 31-37: This paragraph states that PGV’s groundwater monitoring program was stopped in 1995. This is incorrect as the State and Federal Underground Injection Control permits both require continued and ongoing groundwater monitoring. DLNR also requires groundwater monitoring during drilling and geothermal well operations.

Pages 24-25, Lines 38-7: Reference noise levels and permitting requirements. The State is responsible for noise regulation and enforcement. State noise regulation rules were promulgated in 1996. PGV and the surrounding community is in an area zoned “Agriculture.” In accordance with State noise standards, 70 dBA is the allowed noise levels. In regards to BACT, PGV has maintained the use of BACT from the beginning of GRP-1.
Page 25, Lines 8-15: PGV and the surrounding communities are not designated Class A under DOH standards. PGV and the surrounding area are in Class B (Agriculture) districts.

Page 26, Lines 5-6: States that “all emergency response systems are the province of County of Hawaii.” For emergency response, PGV is also regulated under the State Emergency Response Commission and various Federal programs, i.e. Risk Management Plan, CERCLA and CAA.

Page 26, Line 8: States that “PGV maintains some 25 air monitoring stations on its property.” This is incorrect as PGV maintains **3** air monitoring stations. PGV does have additional fixed and portable monitoring detectors on its property.

General Findings

Page 34, Lines 12-15: Add the sentence, “What other empirical or epidemiological factors, such as lifestyle, economic well being, health care access, diet and environmental factors can account for baseline health and complaints?”

Discussion

Page 35, Line 41: States that “monitoring of exposures has been inadequate.” PGV’s position is that this statement should be clarified or expanded to include that “**Study Group believes that** monitoring of exposures has been inadequate.”

Page 36, Lines 20-22: End the first sentence after the word ”debated.” The remainder is unnecessary and admittedly unsupported and debated, so why have it?

Department of Health

Pages 37-3: Note that the Kilauea and Pu'u O eruptions commenced in January 1983. References to higher incidences of common cold symptoms in Leilani can be attributable to a variety of factors.

Page 38, Lines 42-43: References tort litigation cases against PGV by former employees. For the record, PGV has not and will not voluntarily disclose any work-related personal matters regarding current or former employees to the Study Group.

Goddard & Goddard

This report should be reviewed. Not sure the basis was clear for the conclusions.

Geothermal Health Risks

Page 39, Lines 7-8: See comments for Section 3, page 8.

Exposures

Page 40, Line 10: This sentence seemingly attributes the potential for H2S emission with geothermal and separates it from natural emissions from fumaroles or the rift. This should be rewritten to avoid ambiguity.

Page 40, Line 27: What does the term "above health significant levels" mean in any context? This should be referenced to OSHA standards.

Vulnerabilities

Page 41: It would be helpful to have some comparison table to identify what ppm and ppb means. There should be a consistent reference to H2S level measurements throughout the report.

H2S Exposures

Pages 43-44: The discussions about hypotheticals is unsupported and unnecessary. Even the blowout did not produce the hypothetical levels speculated for the 2005 well cleanout. Moreover, which of the hypotheticals were taken from off site monitors as opposed to plant data?

Page 43, Lines 14-17: To clarify, PGV complies with all aspects of the Hawaii Department of Health Noncovered Source Permit which regulates air emissions.

Page 43, Lines 19-20: To clarify, PGV does report the peak levels of H2S emissions.

Page 43, Lines 22-26: To clarify, this paragraph needs to state that the **"Study Group"** believes the monitoring system is inadequate.

H2S Health Effects

Page 44, Lines 35-37: The use of levels needs to be consistent, either ppb or ppm. Is it correct

or responsible to say that those exposed to long-term ambient fugitive emissions at levels of less than 5 ppb may be at increased risk? Because this is the implication of the statement and no study even suggests this as a risk factor. The purpose of the study is to determine if the statement is correct, or not.

Noise and Vibration

Page 45: Should there be some mention that in the past 10-15 years, coqui frogs are now a permanent presence and contributes significantly to background noise by a certain db level?

Recommended Health Study

Pages 45-46: Other environmental factors or variables such as mold, mildew in differing communities should also be studied. Similarly, for noise effects, the effect of coqui frogs can be measured as between geothermal and other Puna vicinities, as compared against other coqui-free locations on the island. And for anxiety, how does demographics and economic well being play between communities?

Page 51, Line 7: PGV offers realtime monitoring at www.ormat.com.

Page 51, Line 42: This is one of the few if only places the report acknowledges similar hazards due to naturally occurring volcanic gases, but there is no recommendation in the report to look for background data on hazards that exist due to Puna's location on the rift. We recommend that the report include a recommendation to understand the health and environmental hazards that exist in the local environment as baseline information. Only then can potential hazards be understood due to geothermal development.

Seeking and Selecting Researchers

Page 53, Line 36: The preparation of request for proposal also needs to be reviewed or overseen by disinterested scientists.

Pages 54 and 55: There is a disconnect between the goal of getting proposals which are unbiased, and how proposals get created and selected. The Committee should be comprised of disinterested members of the community (not necessarily from Puna, as well as scientists, who can best articulate methodologies). Input from others can be considered. But having come up with the recommendations, the panel members should not be part of the committee or the selection decision making, exactly because their work is done, and some have already advocated using certain "experts" whose penchants for taking a certain position and whose willingness to take other work (such as serving as experts in litigation) may taint the analysis. If industry representatives are not allowed to sit on the panel or create RFPs because of a perceived bias, so too should community representatives not be part of the RFP preparation, solicitation or selection process.

17 August 2013
To the committee on health study:

I am a three year resident of Leilani Estates and I have been following the progress of your committee by reading about it in the newspaper, attending public meetings, and reading the website of the Puna Pono Alliance. When I moved to Leilani I was aware of the presence of the geothermal power plant. I chose a home as far from the plant as possible but still located in Leilani Estates. At the time, I did not know much about geothermal power. I noted that it had been there a long time and that it did not produce emissions on a continuous basis. It did not seem like a threat to me, but common sense dictated that if I wanted to be in a residential setting, it was prudent to live well away from a power plant.

My main concern with the document your group has produced is that it does not address the needs of Big Island residents as a whole, or me as a civic minded resident who will be impacted by policy decisions made as result of your committee report. Your group appears dominated by a small group which you identify by the vague name "community", but a group of which I am not a member. Most other island residents are not members either.

To me the most troubling recommendation which has emerged is the insistence that the contractor to be hired to design and conduct the health study not be chosen by an open process. Many of your study group members want only one contractor to be considered. By doing so, a small group of individuals who are not public health professionals will be given the authority to hire a person who may or may not be the best choice. These individuals are putting themselves and the county risk of long range lack of confidence in the whole process. It will greatly decrease the public acceptance of the results as well as the procedure by which the county chose to bring the study committee together.

If the county sets up a procedure to request proposals from all interested contractors, and informed health professionals choose the best applicant, then residents will have confidence that the best available study will be undertaken. Their public money will be best spent. It is possible and maybe even likely that the individual that Puna Pono prefers will be awarded the contract. In this case, everyone will have confidence in the conclusions reached by the study.

I, for one, will always wonder what everyone had to hide by insisting on a single particular contractor. If this endeavor is to be a democratic process, then best interests of all island residents should be reflected by the actions of your committee.

Sincerely yours,

Alice Lindahl
Leilani Estates
Ph: 936-6376
alindahl@hawaii.rr.com

First Name:	Barbara
Last Name:	Rogers
Email Address:	bjrrich@comcast.net
Phone Number:	503-803-7949 (c)
Comment/Question:	I have just read the excellent Draft V-3 published July 27th,2013. Geothermal Public Health Assessment/Findings and Recommendations. I support the scientific and unbiased approach to evaluate possible health hazards of Geothermal. A scientific approach provides a better outcome study than does antidotal information. Please accept recommendation #5, assuring credibility, reliability, and unbiased research.

First Name:	Richard
Last Name:	Rawlinson
Email Address:	bjrrich@hawaii.rr.com
Phone Number:	808-965-5665
Comment/Question:	I have read the documents relating work of the group studying the geothermal energy matter in Puna. I support the steps prescribed in Recommendation #5.

(4)

Cynthia "Destiny" Edwards
13-1359 Lauhaletele Rd Pahoa 96778

I had the privilege of helping Puna Pono by manning the informational tables at Island Naturals and Cash n Carry. This was mostly a positive experience but I was approached by many people with stories of relatives who have suffered everything from extreme respiratory problems to birth defects and cancers my heart went out to these people because they have suffered so horribly both physically and mentally due to the effects of Geothermal noise emissions etc. I am especially sad because they have no unified voice to tell their stories. Has anyone made any effort to even look at the long term problems and compare them to today? Is there anyway to get support when you have suffered damage?

Aloha I would like to thank this group for working for so long and hard on this report.a I would also like to say that this was an unnecessary undertaking. We as a community worked long and hard to educate the last county council on the fact that we needed a health study in lower Puna mostly concerned with the effects of emissions from the Geothermal Plant. They voted almost unanimously in favor of our proposal. Our proposal stated that we the community most affected wanted Dr Kilburn a leader, if not the most respected name in Hydrogen Sulfide H2S exposure and its affects to do this study. Nowhere in this study is his name mentioned and the communities desire for his leading the Health Study. WE WANT DR KILBURN TO DO THIS STUDY.

We are an educated community in the ways of geothermal legislation and health studies. We realize H2S and its health effects is a worldwide problem. Industry, corporations and then government with its ties to industry do not want and will do everything in there power to stop a definitive study that shows low level chronic emissions of H2S into surrounding communities make people sick. A study that proves this or is even somewhat conclusive would open the doors to every lawyer to sue for damages in many industries to numerous to mention here. Study would be BAD FOR PROFITS!!!!!!!

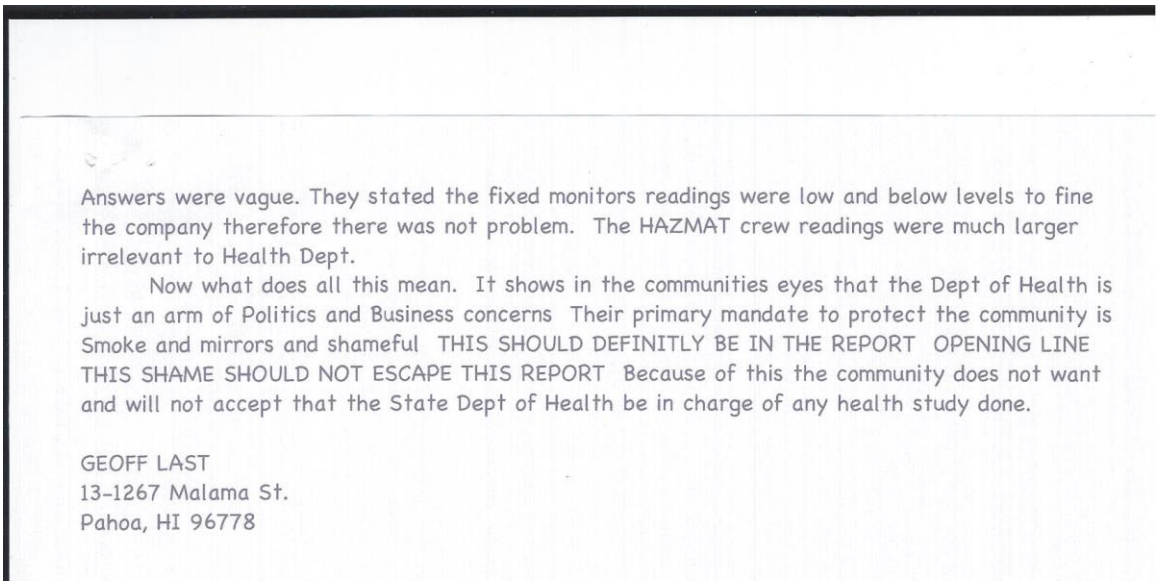
The report as read does not really address the need for BASELINE MEASURMENTS to take place both in the field of health and water resources. Ocean and aquifers. The report dance this topic around instead of the outright statement that these need to happen. They should have happen 25 years ago when the community demanded them. The report implies we do not know what is causing the health problems so how can we do a baseline health study THE COMMUNITY AFFECTED WANT A H2S EXPOSURE HEALTH STUDY DONE BY DR KIBURN

Not good monitoring, no results, no problem - industry and governments policy. The report mentions that monitoring of toxic releases from Geothermal need to be better No real concrete ideas brought in from experts. The community has asked an expert. His statement is Good monitoring as I understand it occurs when you have the quantity of release from the source not in the plume. Then modeling of atmospheric conditions. He also stated that the hourly average notion is flawed in favor of the industry. Makes common sense a big toxic release for a few minutes then nothing gives the impression of a low level emission while in fact a cloud of toxicity is floating around in the community.

More on monitoring EPA is supposed to monitor air and water in this country. It does not have the manpower so it designates the State Dept Of Health to monitor. Then the Health Dept gives the monitoring over to the company in this case PGV. Whenever I mention this to big Mike at PGV he just gets a big smile on his face. THE OLD FOX HENHOUSE ROUTINE DOES NOT PROTECT THE COMMUNITY.

Finally I would like to talk about the state Dept of Health. In the 1980's the Dept of Health sanctioned the policy of open venting of geothermal gases and dumping the effulent on the ground in unlined ponds. The Dept of Health knew about H2S in steam. They new about the heavy metals in the steam and brine. School buses drove through clouds of this gas. Everyone in the area was on catchment getting contaminants in their water supply. After the blowout they refused to check our water tanks for contaminants THE DEPT OF HEALTH SAID THERE WAS NOTHING TO WORRY ABOUT.

Now most of you say this is old history. 25-30 years forward Large Plume gas release March 13. Community fearful calls a meeting invites Civil Defense, Health Dept and others. The State Dept of Health did not send any Rep to the community meeting. Letters were written.



Answers were vague. They stated the fixed monitors readings were low and below levels to fine the company therefore there was not problem. The HAZMAT crew readings were much larger irrelevant to Health Dept.

Now what does all this mean. It shows in the communities eyes that the Dept of Health is just an arm of Politics and Business concerns Their primary mandate to protect the community is Smoke and mirrors and shameful THIS SHOULD DEFINITLY BE IN THE REPORT OPENING LINE THIS SHAME SHOULD NOT ESCAPE THIS REPORT Because of this the community does not want and will not accept that the State Dept of Health be in charge of any health study done.

GEOFF LAST
13-1267 Malama St.
Pahoa, HI 96778

B. Summary of Comments from the August 15, 2013 Meeting

1. Martin Blackwell – stress response expert – recommends the group (and the audience) adopt his "instant aloha method" to help make better decisions. We need to slow down, breathe in the aloha spirit, and not rush into a decision about geothermal until all the facts are known and well thought out.

   Martin (second comment) — haste makes waste. He will hold out a ray of hope for this group and this process for the Study Group to breathe, slow down, and make the right decisions. Include the Native Hawaiians in process. He offered his services as the bridge in that process. We cannot ruin this or have a horrible result because we aren't making the right decisions. When all sides can be present, including DOH, maybe we have a chance, but until then we will have problems.

2. Chris Biltoft– meteorologist – atmospheric dispersion modeling needs to be in recommendations—can't do it with monitoring alone. It can give HAZMET the info they need in case of emergency. Hour averaging is not appropriate for our geothermal situation here because toxic plume enters community within minutes of being released from PGV. You need a measurement and response capacity on the order of that minute.

Bob asked what level of H2S could people be exposed to without violating the 25 ppb average. 63 ppb for 1 minute. Readings of 3000 ppm not a violation—this is Not Right.

3. Joyce Folena – 30 years Puna – she was going to say what Chris said. The report is way better than she ever expected. Kalapana Seaview Estates gets downwind effects that stretch from Opihikao to Kehena Beach. Post blowout and other geothermal incidents since then, her symptoms are: diarrhea, shaking, headaches, and clear liquid comes from her nose. Doctor said it was nothing; she thinks there is a cover up going on. Dr. Sam Ruben as head of DOH collected stories of the health problems. She took folks to see him as far away as Ainaloa, so she believes the affected areas are much bigger than previously thought.

   Joyce (second comment) – She does not have a reaction to hydrogen sulfide, only H2S; there is a big difference. She was here during the 1980s when there was a lot of Pele action and vog, but she did not have any health problems nor does she have any when she travels Kona side. Every time there is a geothermal incident—well blowouts, clean outs, venting – she always has health problems.

4. Greg Smith – was here during blowout. Impressed with this group and the process going on here. Still, it's more or less a thumb-sucker because we should have gone directly to health studies. They have been recommended and obvious for a long time. We need baseline studies, particularly along coastal areas, including the fish. This is a good start—mahalo.

5. Geoff Last– thank you for this report, but it's unnecessary as we already educated previous county leaders on doing this with Kilburn. His name isn't mentioned in the report and we want him. H2S is worldwide problem and definitive studies will change geothermal all over the world. Need baseline studies, monitoring. EPA does not have manpower to do their job, nor does DOH, so it passed to PGV. Catchment, school buses, all affected—no studies or tests were done. We don't want DOH involved in any health study—they are liars.

6. Paul Kykendall– mahalo to the study group for their tangible and useful work for the community. He appreciates the recommendations, and they all need to be done to insure health of community—hasn't been done well for 37 years since 1976 with first HGP-A well. State failed the people: it should protect community, but doesn't—it's theirs and County's kuleana. By doing this report, the health studies are again delayed. Please do not wait another year to do this. Why haven't the county and state responded? Mahalo for your efforts.

   Paul (second comment) -- State promotes geothermal because it wants money and county gets something reg difference. State wants money, county gets

something. State promotes geo to get money, Puna numbers are low compared to rest of state. Spirit needs to be honored in Puna. Evacuate the people, don't protect them—get them out of the way before the next disaster.

7. Suzanne Wakelin– the report does not contain a definition of the word "health." This definition determines the safety and impact on communities that go beyond medically diagnosable disease. DSM definitions are irrelevant to health of residents. There are impacts from noise and vibration that may not result in a DSM condition. She agrees baseline study needs to be included—the community needs protection.

8. Jim Albertini – was arrested years ago for his resistance to the K8 well. Commends the Study Group and good faith efforts. He supports everything, and he has some additions. Also supports PPA position in the email it sent out yesterday. Pele Defense Fund video, "Pele's Appeal," raised profound questions about Hawaiian healing efforts and how they are thwarted by geothermal actions. His main recommendation, to be included as a separate action, is a comprehensive study on native Hawaiian religious practices. It should be the first recommendation to honor Pele and the host culture. Add the video to the bibliography. Study Group should also recommend moratorium on geothermal until safety is determined. (letter included in previous section)

9. Samuel H. Kaleleiki-- Nobleman in Kingdom of Hawaii – money talks and "bs" walks. Kanaka Maoli (KM) like me are the real people—no one asked us about this—and none involved in this geothermal stuff. There are Hawaiians, but no KM. There were 800K-1 million Hawaiians here before, but not now. Snowden knew to go to Russia—Hawaii is not the United States. It's all about money.

   Samuel (second comment) – he testified at county council about tourism. He needs permit to get into his own forest, but tourists can drive their cars into it. His government is the Hawaiian Kingdom. Western government is liars and brought greed, hatred, jealousy, and the poisonous snake. We KM are the real ones who are now being told what we can do and say. It took 120 years to destroy this paradise. He proudly served 30 years in the Marines 1950-80 and earned the rank of Sgt. Major.

10. Palikapu Dedman-- Hawaiians have been neglected in this issue and in the study. We are always left out—no consideration that Hawaiians were not included in the Group. We should be, but we are not. Our concerns don't matter, and there is no consideration that Hawaiians are more impacted, less respected than others. Study Group should raise issue that the host culture is not represented. It's missing in the study. Hate, racism, not good, Hawaiians are here today to be seen.

11. Rocky K. Jensen -- I no got aloha for you guys. Been here for 2500 years, and we are not the host culture. #1 recommendation should be host culture. I'm 70 years old, 35 years wood carver—I'm out working while you are asking questions. Somehow the 'aina got detached from me, leaving us Hawaiians to fend for ourselves while others come and poison all of us. He helped build the hotels, wants us to go back to Vegas.

12. Norris Thomlinson – it may be repetitious, but I wanted to add my voice. Hawaiian input must be there, please recommend holding off on expansion until all recommendations have been addressed.

13. Leimane Pelton -- 33 year resident – all life is in this too—soil, trees, water, us. There is an unusual die off of Ohia trees, especially around PGV. UHH was asked to check it, but would not come because it's 'natural.' NO! These are indicators of problems. If an Ohia can die in 2 weeks—what is happening to the kids? Put the poison back into the ground instead of into the air—where does it go? I worked with a 3M monitor near the volcano, but it showed no exposure. I never had allergies before moving here (near PGV). Never got sick before, even when working around volcano, so it must be PGV/geothermal activity.

14. Ronald Fujiyoshi – member of Pele Defense Fund since 1988 and missionary in Asia for 20 years. He was arrested in 1990 (with Bob?), and has followed geothermal development. He hasn't changed his mind: geothermal is not clean and it's not renewable, and he's against it. Impact on host culture is big. Talked about a book—"Before the Horror—Hawaii on the Eve of Western Contact." Book labels "genocide" anything that is not working to preserve and protect Hawaiians and the environment. Those who live here are either committing genocide or helping make it better. Hawaiians' impact—not just the assimilated ones—should be in the report.

    Ronald (second comment) – pastor and community organizer. Big problem is that geothermal is worth millions, so problems are being ignored. This report could have been written without any research—we knew all this before you started. When are you going to write your individual papers on this? He wants to see who has the guts to speak out on this political issue. We are dealing with a huge monster here. We need to put ourselves on the line with the individual reports. Trying to be realistic, but we have to be brave to go up against this million-dollar industry.

        Rene explained that the individual papers will be on topics that are not unanimous from the group.

15. Ole Fulks – he's not going to repeat all that has been said, but wanted to share a story. He lives without electricity, not sure why we need it. Has battery operated

TV. During 1990 blowout, could not hear his TV from PGV noise. Promises that geothermal is safe or that the problems are fixed are not true.

16. Leslie Wingate – moved here 1 year ago, did not know about his before. Pele practitioners believe geothermal drilling is desecrating Pele. Native Hawaiians believe Nature is sacred, Westerners do not. Geothermal psychologically impacts those with Hawaiian beliefs, can cause damage, and that should be included. She wants Kilburn and also to include Legator. Mahalo for acknowledging people are suffering from geothermal. Top priority should be to work with KM—it's their home we need to respect it.

17. Avery Freed – ex radiologist from Oahu living in Opihikao. H2S is same as radiation—need protection from it and more information about it. He agrees with the ideas that came before him—we need all the recommendations included. He wants health for people and animals.

18. William Boatman– the difference between life and death is HA, breath. We are mirrors of each other—but we aren't seeing this. The sickness is here—it's the retribution for our disrespect. We have to take care of our land. Geothermal is not right, it's poison. What goes around comes around. This is the fruit of our actions. We need to respect—we need to make this right. He's disgusted with all of it.

19. Andrea Rosanoff – nutrition researcher. Loves living here. Findings are good, but need #4—Assessment of the regulatory structure in place and what is needed between geothermal and people. Re #2 Recommendation – meta analysis of H2S -- is not enough. It's a good and useful tool, but it's only a tool. It does not take the place of a comprehensive review of all the studies including the selection process, elimination process, and how data is parsed. We need to preserve the beauty here.

20. Jahanava Baldassarre – retired nurse living 8 years in Black Sands. Fed, state, county agencies need to respond to residents' concerns—Mahalo for validating us. This report is good. We need outside monitoring entities and real time data to build trust. PGV is non transparent. On p. 118, preliminary test results, underscores the need for monitoring—I recommend adding "AND before any other geothermal activities are undertaken." Agrees with more monitors, including the fire department. P. 29, what future studies are needed, add baseline study with Kilburn.

21. Nohea Crutcher — Puna is Pele's home, and living here makes it your kuleana too. Her energy is in the heat and the steam, and you are desecrating her with geothermal activity. More non Hawaiians respect Pele than Native Hawaiians—that is sad. We need to listen to nature—vog is Pele's too. Upset at DOH for not doing their job. March 13 release they did not come. Need to have time limit on when they have to get down here. Need monitors—down low especially.

PA –acknowledged Nohea for her good works and help and attendance at all of our meetings.

22. Cynthia Evans— while working tables at PPA events, she heard many health stories. She realized there is no clearinghouse or place for people to tell their stories, no comparisons, no statistics, no voice for average person. Most people with stories are isolated and do not know there are others and/or what could be the cause of their symptoms. She knows of one lady who was cleared by her doctor on March 9, and on March 20 after blowout, was diagnosed with full-blown COPD. Mahalo for time and effort—look at everything.

23. Radiance Grace – They did health study in 1995 when she was first here. When will folks take these studies seriously? Why is no action being taken? We're stuck in a conundrum—our side and their side, but no action. She is frustrated because she's clear about facts—are the folks in power not clear? Are they trying to pull the wool over our eyes? You cannot fool the public anymore because of the Internet. When will she see the findings/results/comments making a difference? She's confused.

24. Michael Kelly – he's new around here – behavioral pharmacologist -- about a year from HNL. He did not anticipate having issues with geothermal, bought the 'good' story. Industry dismissed the March 13 event readings as not being high enough to worry about. He differs—H2S induces fear and anxiety. H2S nuisance level (strong smell, nausea, headache), science says it induces PTSD symptoms in war victims, reflexes for anxiety, and host of other measures of increased anxiety. At neurobiological level, nose is connected to the Amygdala, which gets all excited from H2S smell. It also activates hortotropic (?) release factors and other receptors.

    Michael (second comment) -- people are suffering all over the world. He worries the state will put this report on the shelf. He doesn't think they will do anything. He suggests a different model—heavy industry should pay a tax according to how invasive the activity is to the earth and to people. New folks could make the same mistakes HGP-A made. He doesn't think a single study will do it. We need a guru in toxicology; we could become the center for toxicology worldwide. He disagrees that Kilburn is the right person—he's old. Takes years to get started, years to complete. Need young buck because 35 years from now geothermal will still be around.

    Rene – we share the concern that this report will go on the shelf, but we

    don't have any mandate here except for the health study. He sent a letter to repeal Act 97 as a start. OHA has been getting money from geothermal, and now they want to get involved in the production without consulting

the community. Perhaps OHA beneficiaries should get involved in telling OHA about their concerns.

Bob – his concern is also that the report will have a subjective interpretation according to the reader's bias. His goal is to limit that possibility in the report.

Michael (third comment) – meta analysis doesn't always solve issues. One must ask the right questions. Can the group speak to that?

Jim—meta-analysis is a tool. He wants a real review—verbal and statistical. How big are the magnitudes we're dealing with? CNS has large responses to small doses. If we knew something about effect size globally, we could compare. Variability does not mean there isn't an effect.

25. Jon Olson – his first concern about health study was it would be another stumbling block to the EPA emergency response plan of 2000. He spoke with Darryl Olivera at Civil Defense. Engines have CD monitors and there is now some backup (?) he also worked with Legator and he is wonderful. H2S always tied to something else, paired with other molecules.

    Rene asked if his EPA report contained her remarks—he does not know. Legator seems like he was a threat—Inouye spoke negatively about him. He must be quite a threat.

26. Unknown woman—it's sad that Native Hawaiians were left out of report. Please right this wrong—do not let it go forward without consulting them. She's deeply offended at this oversight.

    Unknown (second comment) – are you discussing recommending a moratorium? Bob said you were told we couldn't do it, but he will include it in his paper. If this report has teeth, we hope it will have the effect of a moratorium on further development.

27. Dave Kizor – this is Native land and they are pretty much left out of it—should be righted. Wants Kilburn and Legator.

    Dave (second comment) – to add to the meteorologist's comment, we need a monitor at the source so we can know the actual dosage at the time of release.

28. Lady with English accent (not on speaker list) — stabbed a pencil repeatedly through a Styrofoam meat tray labeled Hawaii. Starting with earthquake insurance being too expensive—there have been four recently, she stabbed the plate as she read

off each transgression against the ‘aina, including geothermal. She held up the “holy” plate saying Hawaii will be destroyed by all the wrong doings.

Lady (second comment) — Pohoiki resident who loves the clean weather -- held up “holy” meat tray again, saying this is a catastrophe now. She has been here for two incidents, and she, her daughter, and her cat all had symptoms. There is a correlation between PGV and health incidents. A statewide class action suit will be too late. Do the “fracking” away from people. Held up the tray and said this is where we are going.

29. Nicky Spencer – lives in south Kona. Doesn’t understand that if there is one person suffering from geothermal, why isn’t that important enough to address the problems? Tutu Pele is being desecrated in this process. Consider the 7-generations hence rule. Find a way to live on the ‘aina—Pele is all we have. We are all ONE. Whatever you do to someone, you do to yourself.

(EVENING SESSION)

30. Jeanne Holmes – lives a few miles downwind from PGV. When there are problems, she gets issues with her health—respiratory problems and feeling sick, noise stress, and sleep problems.

31. Kurt Kave -- carpenter/builder living a little more than a mile from PGV -- doesn’t know environmental issues, has no issues that he knows of, but feels he has stress impacts from hearing about it on news and from friends. Why are folks working on Group voluntarily? Mayor is pro geothermal, so he will probably have reasons why we don’t need to do study. Monitoring is very good. He’s heard there are records, but he can’t find and hasn’t seen any of them. Wants transparency. He’d like to see over time. Evacuation plan is hugely important—with tree down along Lava State Park Road, evacuation routes are severely hampered.

    Bob noted that DOH and Civil Defense have not been cooperative on the issue of historical data. There is no access right now to data.

32. Joyce Molina – 30 years in Puna. Wants Kilburn even though he’s old—should name a successor in the event of his death. He forced oil and gas industries to clean up their acts when they were polluting with their toxic waste. Kilburn is too good; he’s a problem to industry, not the people.

    Jeff -- as hard as we’ve worked so far, we can get the stamp of approval from county, and that’s about all we can do. We are powerless to ‘do’ anything. The people have the power to have the best chance for the report to be implemented.

Jim — access to historical data is an issue. We recommended a web site to continuously monitor releases that would include the historical data.

33. Walk-in Man -- can hear low frequency right now, came from home to talk about it. Exec summary p. 21, geothermal is renewable resource, but then you say there are areas where it does cool down eventually. Can both be true? On p. 15 line 42, re stress not being a problem—it IS! Maybe not acute stress, but low level stress is a problem.

34. Sara Steiner (lady who came in late?) — read from online report. Conflict of interest statements—PA did disclose his previous work with geothermal, but the problem is after we gave you our input, you did not include it the report. It has harmed the residents here through today, and casts aspersions about PA bias. Should not say, "after 1993, no effects" – it's not true. You say Lower Puna rep is Wild West; she doesn't like that reference. On p. 20, the scope of study needs to include the fear and anxiety over fear of more geo development. H2S guidelines have been lifted, but that is not in report. Wants to remind the group that info in report does show harm. Wants Kilburn as a good faith effort. We cannot be vilified for living in Puna. She appreciates everything we've done.

    PA – he's valued the process—tough as it is. He has learned how tough the science is on H2S, especially the lack of exposure data. It has presented a huge stumbling block for this report.

    Tom – we've made a lot of recommendations — asked Mike from PGV to give feedback -- he said yes.

    PA—Mahalo to all members of the study group for their hard work.

Martin Blackwell
awarenessrecovery@gmail.com
808-989-9849

Aloha, A basic awareness of the baseline stress response is by far the most critical factor in determining the health and environmental risk and impacts of geothermal energy harnessing. Unfortunately this has been proven to be greatly lacking in our current society to our own detriment, thus minimizing our health and future outcomes. Unless individuals are truly aware of their baseline stress response they are at risk of blindly pursuing resources without awareness of impact. This is due to individuals seeking a level of comfort that is unattainable, operating on unaware

fear driven greed. We have failed as a health system and society creating a false baseline of pure calmness and happiness that does not allow for the required stress, tension and anxiety required for survival in a food chain. Current research supports this as we see the devastating impact of an obese society wasting food and resources in a failed attempt to escape their natural protective fight or flight tension. All individuals involved in any major resource management decisions would need to be aware of the relationship between the stress response and resource management to make effective decisions that are not ultimately life threatening. The baseline of any health study would have to include the baseline of the stress response which in western society has been completely distorted due to a desire for total comfort. Performance and Anticipation Anxiety can easily be proven as our baseline, as we are in a food chain capable of being killed by a multitude of variables at any instant. We have recklessly mislabeled anxiety as a multitude of mental and physical disorders and wasted exhaustive amounts of resources, and exposed people to unneeded harmful intrusive side effects for decades. I have personally proven this as a therapist and an expert in human behavior with on hands research and application that is supported more and more by current research. It would be reckless for this study to recommend anything but updated health studies with an "accurate baseline" that holds all accountable for their baseline anxiety/stress/tension and all the health conditions that can occur from a lack of awareness of that baseline and mismanagement of it. It would also be reckless not to request a moratorium on all geothermal expansion until this baseline study occurs and all those involved in geothermal promotion and decision making have a thorough awareness training of their own baseline stress response and how they are at risk of blindly going forward unaware of the long term consequences caused by the pursuit of instant gratification. "Haste makes waste." We are at risk of wasting our future by making unaware greedy self-gratifying decisions in the present. I will gladly provide this desperately needed community service for all involved. This is simple common sense that can be understood by a four year old who is willing to wait, rather than grab anything they want at anyone and everyone's ultimate expense, including their own. I look forward to hearing from you to be brought into this process as soon as possible, as to my knowledge, no one thus far seems to be an expert in the stress response as it relates to resource management, which is what this whole process and issues are about. I am more than willing to provide my 25 years of expertise to help resolve this critical community safety matter. Mahalo for your efforts thus far, but it is obviously time to "Stop the Press" and ensure optimum awareness and accountability for community safety and sustainability. Sincerely and with much aloha, Martin Blackwell, Stress & Resource Management Specialist Owner of Optimum Health & Futures 808-989-9849.

Concerns Pertaining to the *Geothermal Public Health Assessment Findings & Recommendations Report*
August 15, 2013

First, I wish to thank the authors of this impressive body of work for their precious time, diligence, and sincere pursuit of parity.

I would ask for your consideration of the following important inclusions within your Report*:

- Include as one of the Report's* "Narratives" the strong opposition to geothermal in Puna by the native Hawaiian Pele practitioners.
- Include in the Report's* Executive Summary:
  The necessity for additional and adequate: health impact studies; emergency response; monitoring; and regulatory control. Plus, an investigation of the State limits on H2S exposure to determine if they are currently adequate.
- Include Dr. Legator's Study (the health impact of geothermal development in Puna on its communities) in the Report* and in its Bibliography.
- Set guidelines for identifying and protecting individuals most at risk from geothermal emissions and other potential danger from geothermal plants.
- Identify evacuation ways and means.
- The following comments pertain to:
  V. Specific Recommendations: E. Seeking, Vetting and Selecting Researchers

  I believe the County's participation on the RFP Selection Committee should be less, with members of the lower Puna community impacted by geothermal development making up the greater part of the Selection Committee. I believe the best role for the County would be as advisor and facilitator to the Committee concerning County procedural and legal matters; as such, the County could effectively participate outside of the Selection Committee; otherwise, County participation on the Committee should number no more than 1-2 members.

  Members of this report's* study group should definitely be encouraged to participate on the Selection Committee. The number of participants on the Selection Committee may require further discussion.

  Recommend an independent, neutral, not-for-profit entity be selected to administer the RFP.

**Geothermal Public Health Assessment Findings & Recommendations Report*

Robin Stetson, Leilani Estates

August 15, 2013

Comments on the Adler Report

The Puna Community voice must be given a heavier weight throughout the process, as the County and State agencies involved have been remiss in their obligations to the public.

Dr. Kilburn should be the scientist to conduct the H2S studies.

The Legator Study should be mentioned.

The Puna community has been used as unwitting guinea pigs throughout the current geothermal development. Baseline studies of air quality, groundwater, soil contamination and health should be done before any serious consideration of future geothermal development.

List of possible affected communities should be expanded to include Hawaiian Paradise Park in light of Mililani Trask's recent comments to Office of Hawaiian Affairs Board of Trustees where she mentions IDG developing the geothermal the resource at Maku'u.

Since the State and Federal agencies whose duties it is to safeguard public health are generally staffed with former or future members from the businesses they are supposed to be regulating, they cannot be trusted to provide unbiased information. Therefore, people from impacted communities should have more room at the table in order to compensate for this defect.

The report does not describe in detail what a worst case scenario might look like, and how woefully inadequate are the plans now in place to deal with this possibility.

The most fundamental laws of the universe seem to be Murphy's Law and the Peter Principle, so these should be foremost in the minds of people at all times.

The trade winds are diminishing, and this needs to be factored in. In addition, there appears to be increased seismicity since geothermal started here.

Vicki Vierra
Kea'au, Hawaii

3 Bibliographic Resources

This selected bibliography, along with the materials in Annex-3, is intended to serve as a usable resource for the County of Hawai‘i government and the public as they confront health questions associated with geothermal energy production. It has served as a running reference for the Study Group during its deliberations. It is not meant to be a complete inventory nor have the studies been academically vetted. (√) Notes articles from peer-reviewed journals.

A. PGV and Health Assessments of Surrounding Communities

1. (✓) Agency for Toxic Substances and Disease Registry Division of Health Assessment and Consultation. (1997). Health Consultation: Puna Geothermal Venture Pahoa (Puna District), Hawaii County, Hawaii. *U.S. Department of Health and Human Services.*

   Synopsis: A health risk assessment of Puna Geothermal Venture was conducted to measure chronic exposure of hydrogen sulfide emissions. The Agency for Toxic Substances and Disease Registry Division (ATSDR) examined the geothermal wells, the geothermal plant proximity to nearby residents, collected air monitoring data to measure ambient air quality, and monitoring data from geothermal monitoring stations. After the examination, it was concluded that the air around the monitoring stations in residential areas near the site do not pose a public health hazard. However, in the event of an unplanned release, high concentration of hydrogen sulfide at the level of 1,000ppb would result in public health injury.

2. Anderson, Bruce S. and Neil M. Oyama. A study of the health status of residents in Puna, Hawaii Exposed to low levels of hydrogen sulfide. (February 1985). Published by Research & Statistics Office, Hawaii State Department of Health.

   Synopsis: Residents living downwind of a 3 megawatt geothermal power plant on the Island of Hawaii and exposed to hydrogen sulfide at concentrations ranging from below the detection limit to 11 ppb (based on one-hour averages) were surveyed in February, 1984. With the exception of the "common cold," no differences in the prevalence of self-reported acute and chronic health conditions or various measures of disability were observed when rates of all health conditions were compared to a similar, unexposed community in the area. However, both the study and control communities had relatively high rates of chronic respiratory conditions when compared to Hawaii County and State-wide rates. Further studies are needed to determine what factors may account for the apparent high rates of chronic respiratory disease reported in this area.

3. Brooks, A. Barbara. (1993). Evaluation of potential adverse health effects from short-term exposure to hydrogen sulfide resulting from an unplanned release from geothermal wells in Puna, Hawaii. *The Hawaii State Department of Health Hazard Evaluation Office.*

Synopsis: Using a worst case scenario, Dr. Brooks assessed the maximum predicted hydrogen sulfide concentrations of 12,78 ppb and its exposure to residents living approximately 6,000 feet and 20,000 feet from Puna Geothermal Venture. The study suggests little evidence of serious adverse health effects would be expected in adults and children. Moreover, the maximum predicted levels of hydrogen sulfide discharge are less than emergency levels used by Federal and State regulatory agencies.

4. (✓) Durand, M., & Wilson, J. G. (2006). Spatial analysis of respiratory disease on an urbanized geothermal field. *Environmental research*, *101*(2), 238-245.

Synopsis: Durand and Wilson report findings of chronic exposure to hydrogen sulfide occurring in clustered populations in Rotorua, New Zealand over an 11year span. Their study explores the rates of the spatial patterns in relation to hydrogen sulfide air pollution, and associated health affects. The findings link a stronger association with noninfectious respiratory disease among residents living near the geothermal area than previously reported. Chronic obstructive pulmonary disease and associated conditions are found in population clusters 4 kilometers or less downwind from the geothermal field.

5. Goddard & Goddard Engineering Environmental Studies. (1991). State of Hawaii Geothermal Action Plan Element III part II micrometeorological aerometric and health effects analysis. *Lucerne (CA): Goddard & Goddard Engineering Environmental Studies.* http://evols.library.manoa.hawaii.edu/handle/10524/19341.

Synopsis: An independent study was conducted to verify the measurements of hydrogen sulfide that were released during the uncontrolled venting of June 12, 1991 to June 14, 1991. The study also included measurement estimates of plume concentration and transport patterns where adverse health effects were reported. The results of the investigation found that the estimation of hydrogen sulfide emission levels were in line with the local monitoring station and associated hot spot area measurements. The concentration of hydrogen sulfide presented a significant health risk, which was correlated with health complaints that extended to regional areas beyond 10miles from the Puna Geothermal Venture plant site. The estimated measurements of other toxins that were released posed significant public health risks. Lastly, during the duration of the uncontrolled venting, it was apparent that the permitting requirements for hydrogen sulfide emission limits and the other toxic elements were violated, as well as, violation of noise limits, and underutilization of Best Control Technologies.

6. Johnson, D. B., & Arbeit, W. (1988). A baseline study of the health status of the residents in Kalapana, Hawaii, January--June 1987. *United States Department of Health, Honolulu, HI.* https://www.etde.org/etdeweb/servlets/purl/882391/.

Synopsis: A community health survey was conducted during the first five months of 1987 in Kalapana, Hawaii. Some 676 residents were interviewed during the study, which represents some 82% of all households in the community. The goal was to obtain base-line data on the health status of all community residents and ambient air quality, in order to evaluate any changes in health status of residents after geothermal development in the area. The health status of Kalapana residents (as

measured by morbidity, restricted activity due to illness, activity limitation and hospitalization) is worse than that of Hawaii County or State residents as a whole. Differences are primarily, but not exclusively, associated with higher levels of acute and chronic respiratory illness conditions. While ambient air monitoring indicated the presence of hydrogen sulfide and atmospheric radiation, the levels were not high enough to be unsafe to humans. Some natural volcanic ventilation exists in the study area and is considered to be responsible for the levels of hydrogen sulfide and radiation found in the atmosphere. Wind patterns may bring some of this pollution into the study area. It is unlikely that geothermal wells operated in other nearby communities affect the study area, since previous studies have found no difference in air quality of those communities from the wells.

7. Kamins RM, Chun MJ, Berger AJ, Bonk WB, Siegel BA, Siegel SM, Speitel T, Lau LS, Buddemaier RW, Kroopnick P, Hufen T. (1976). Evaluation of Potential Adverse Health Effects from Short-Term Exposure to Hydrogen Sulfide Resulting from an Unplanned Release from Geothermal Wells in Puna, Hawaii study for geothermal development in Puna, Hawaii. *Honolulu (HI): Hawaii Geothermal Project, University of Hawaii.* http://evols.library.manoa.hawaii.edu/handle/10524/22964.

   Synopsis: In 1974, permission to build a geothermal plant began. In 1976, the drilling for geothermal energy was completed. Various studies and tests were undertaken before and after the geothermal plant was completed to examine for environmental impacts within one-mile radius. The baseline study show no threat to the surrounding area, however, certain elements (such as heavy metals) should continue to be monitored incrementally over time.

8. (✓) Legator, M. S., Singleton, C. R., Morris, D. L., & Philips, D. L. (2001). Health effects from chronic low-level exposure to hydrogen sulfide. *Archives of Environmental Health: An International Journal*, *56*(2), 123-131. http://www.ncbi.nlm.nih.gov/pubmed/11339675.

   Synopsis: In this study, the authors compared symptoms of adverse health effects, reported by residents of two communities exposed mainly to chronic, low-levels of industrial sources of hydrogen sulfide, to health effects reported by residents in three reference communities in which there were no known industrial sources of hydrogen sulfide. The results of this study emphasize the need for further studies on the adverse health effects related to long-term, chronic exposure to hydrogen sulfide.

9. Sorey, M. L., & Colvard, E. M. (1994). Potential effects of the Hawaii geothermal project on ground-water resources on the Island of Hawaii. *US Geological Survey*. http://pubs.er.usgs.gov/publication/wri944028.

   Synopsis: Sorey and Covard provide data and information regarding the potential effects of geothermal development on adjacent ground water resources. Their report investigates groundwater fluid production, warming of coastal ponds from geothermal activity, and groundwater contamination. The authors anticipate minimal effects on the quality of groundwater, although over time the pumping could cause saltwater intrusion in areas within a mile or two from the coast. Pressure changes produced by geothermal activity can occur and could cause decreases in flow and temperature of coastal waters. Unintended blowouts and casing breaks could cause groundwater

contamination if geothermal fluids and gases are released. Therefore, the authors recommend the development of delineation specifications to minimize potential contamination.

10. State of Hawaii. (1984). A study of the health status of a population exposed to low levels of hydrogen sulfide (and other geothermal effluents) in Puna, Hawaii: Preliminary report. *Honolulu (HI): State of Hawaii (executive branch, Department of Health (Hawaii), and Department of Planning and Economic Development).* http://scholarspace.manoa.hawaii.edu/handle/10524/22862?show=full

    Synopsis: Since the development of geothermal wells in 1976, residents leaving near the plant raised concerns of the health effects from hydrogen sulfide being released into the atmosphere. A health survey was carried of people living in close proximity as well as residents living away from the plant to see any correlating prevalence in the rate of the number of acute and chronic health conditions in these study areas. The results of the study revealed inconclusive results due to the difficulty of distinguishing whether the point source originated from the geothermal wells or Kilauea's volcanic activity.

11. Study: Test show living near PGV is safe. (1998). *Hawaii Tribune Herald.*

    Synopsis: The U.S. Department of Health and Human Services Agency for Toxic Substances and Disease Registry conducted a test on levels of hydrogen sulfide in residential areas near the Puna Geothermal Venture plant. The study found that concentrations of hydrogen sulfides are similar to those of natural occurrences. Furthermore, maximum concentrations of hydrogen sulfides emitted from the plant were well below the federal agency's minimum risk levels, and thus indicating levels of exposure of causing health problems is no more than that of the exposure from Hawaii Island's natural processes.

12. Szvetecz, Annie. (2001). Geothermal energy in Hawai`i: An analysis of promotion and regulation. *Master of Science Environmental Studies Program, The University of Montana.*

    Synopsis: The business of geothermal energy began in the early 1970's in Hawaii. This was in an effort to develop local cheaper, cleaner, and more effective generations of energy sources to reduce Hawaii's demand on oil. However, the promise of clean energy has been contested by the community who had since felt health impacts from the plant(s). This paper focuses on problems associated with the regulatory oversight of two geothermal plants, Puna Geothermal Venture and the Hawai`i Geothermal Project (HGP-A), and calls for more appropriate energy options.

B. General Hydrogen Sulfide (H2S) Studies

13. (✓) Agency for Toxic Substances and Disease Registry (ATSDR). 2006. Toxicological profile for Hydrogen Sulfide. *Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.* http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=389&tid=67.

    Synopsis: Each profile includes the following: (A) The examination, summary, and interpretation of available toxicologic information and epidemiologic evaluations on a hazardous substance to

ascertain the levels of significant human exposure for the substance and the associated acute, subacute, and chronic health effects; (B) A determination of whether adequate information on the health effects of each substance is available or in the process of development to determine levels of exposure that present a significant risk to human health of acute, subacute, and chronic health effects; and (C) Where appropriate, identification of toxicologic testing needed to identify the types or levels of exposure that may present significant risk of adverse health effects in humans.

14. Bo, Z., & Guo-ming, C. (2009, October). Hydrogen sulfide dispersion consequences analysis in different wind speeds: a CFD based approach. *Energy and Environment Technology, 2009. ICEET'09. International Conference on* (Vol. 3, pp. 365-368). IEEE.

Synopsis: "Hydrogen sulfide (h2s) leakage and dispersion from a sulfide recycle installation in different wind speeds are simulated by implementing a 3D Computational Fluid Dynamics (CFD) model. h2s concentrations of monitor points which represent dispersion contours and dangerous areas have been recorded. Dispersion disciplines and consequences in different wind speeds have been compared. The toxic load has also been introduced as a parameter to compare the consequences. Toxic loads of monitoring points have been assessed according to the concentration variation. Case study results indicate that in a relatively bigger wind speed situation, gas disperses quickly in the leakage jet flow direction, and there is less threat in the direction perpendicular to the leakage jet flow; in a relatively smaller wind speed situation, gas disperses slowly in the leakage jet flow direction and there is more threat in the direction perpendicular to the leakage jet flow. In places near to the leakage source, the concentration of h2s is high and goes up quickly which leaves exposed individuals little available emergency response time. Study results also demonstrate that serious consequences could happen in the potential toxic leakage places. Toxic gas detection system and emergency response plans are especially important."

15. (✓) Committee on Acute Exposure Guideline Levels; Committee on Toxicology; National Research Council. (2010). Acute exposure guideline levels for selected airborne chemicals, Volume 9. *Committee on Toxicology Board on Environmental Studies and Toxicology Division on Earth and life Studies.* http://www.nap.edu/catalog/12978.html.

Synopsis: "Hydrogen sulfide (H2 S) is a colorless, flammable gas at ambient temperature and pressure. It has an odor similar to that of rotten eggs and is both an irritant and an asphyxiant. The air odor threshold ranges between 0.008 and 0.13 ppm, and olfactory fatigue may occur at 100 ppm. Paralysis of the olfactory nerve has been reported at 150 ppm (Beauchamp et al. 1984). Mean ambient air concentrations for H2 S range between 0.00071 and 0.066 ppm. Controlled human data were used to derive AEGL-1 values. Three of 10 volunteers with asthma exposed to H2 S at 2 ppm for 30 min complained of headache and 8 of 10 experienced nonsignificant increased airway resistance (Jappinen et al. 1990). As there were no clinical symptoms of respiratory difficulty and there were no significant changes in forced vital capacity (FVC) or forced expiratory volume in 1 second (FEV1), the AEGL-1 was based exclusively on increased complaints of headache in the three volunteers (Jappinen et al. 1990). A modifying factor of 3 was applied to account for the wide variability in complaints associated with the foul odor of H2 S and the shallow concentration response at the relatively low concentrations that are consistent with definition of the AEGL-1. The 30-min experimental value was scaled to the 10- min and 1-, 4-, and 8-h time points by using the concentration-exposure duration relationship, C4.4 Å~ t = k, where C is concentration, t is time, and k is a constant. The exponent 4.4 was derived from rat lethality data ranging from 10-min to 6-h exposures. The level of distinct odor awaRenéss (LOA) for H2 S is 0.01 ppm (see Appendix C for LOA derivation). The LOA represents the concentration above which it is predicted that more than half the exposed population will experience at least a distinct odor intensity, and about 10% of the population will experience a strong odor intensity. The

LOA should help chemical emergency responders in assessing public awareness of the exposure due to odor perception. Thus, the derived AEGL-1 values are considered to have warning properties. The AEGL-2 was based on the induction of perivascular edema in rats exposed to H2 S at 200 ppm for 4 h (Green et al. 1991; Khan et al. 1991). The AEGL-3 was based on the highest concentration causing no mortality in the rat after a 1-h exposure (504 ppm) (MacEwen and Vernot 1972)."

16. (✓) Committee on Toxicology; National Research Council Fiedler, N., Kipen, H., Ohman-Strickland, P., Zhang, J., Weisel, C., Laumbach, R., ... & Lioy, P. (2008). Sensory and cognitive effects of acute exposure to hydrogen sulfide. *Environmental health perspectives*, *116*(1), 78. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2199294/.

Synopsis: Although some symptoms increased with exposure to hydrogen sulfide, the magnitude of these changes was relatively minor. Increased anxiety was significantly related to ratings of irritation due to odor. Whether the effect on verbal learning represents a threshold effect of H_2S or an effect due to fatigue across exposure requires further investigation. These acute effects in a healthy sample cannot be directly generalized to communities where individuals have other health conditions and concomitant exposures.

17. Environmental Protection Agency. (1993). Report to Congress on hydrogen sulfide air emissions associated with the extraction of oil and natural gas (EPA Publication No. 453-R-93-045*). Research Triangle Park, NC: U.S. Environmental Protection Agency.* nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=00002WG3.txt.

Synopsis: The Environmental Protection Agency finds that the potential for human and environmental exposures from routine emissions of H2S from oil and gas wells exists, but insufficient evidence exists to suggest that the exposures present any significant threats. On the other hand, an accidental release of H2S from an oil or gas well could have severe consequences because of its toxicity in high quantity and its potential to travel significant distances downwind under certain circumstances.

18. (✓) Farahat, S. A. & Kishk, N. A. (2010). Cognitive function changes among Egyptian sewage network workers. *Toxicology and Industrial Health.* 26(4): 229-238. http://www.ncbi.nlm.nih.gov/pubmed/20237195.

Synopsis: An investigation was aimed at sewer workers' exposure to hydrogen sulfide and its effects to their cognitive functions. A total for 33 workers were subjected to clinical neurological history, estimation of urinary thiosulfate, and assessment of cognitive dysfunction. Among exposed workers, the study revealed significant neurological issues associated with headache, memory defects, and lack of concentration. Tests results showed delayed reaction time and poor performance on most of neuropsychological tests. These symptoms marked above are in conjunction with exposure to hydrogen sulfide, which are linked to cognitive impairments among sewer network workers.

19. (✓) Guidotti, T. L. (2010). Hydrogen Sulfide: Advances in Understanding Human Toxicity. *International journal of toxicology*, *29*(6), 569-581. http://www.ncbi.nlm.nih.gov/pubmed/21076123.

Synopsis: The study addresses the past controversies about hydrogen sulfide on human toxicity, chronic exposure, and offers a deeper look into understanding its effects. According to Guidotti,

hydrogen sulfide ranks second next to carbon monoxide as the most common cause of gas exposure in the workplace. Exposure levels at 150ppm for 6 hours can be fatal for humans. The agent can lead to a "knockdown", which is a hydrogen sulfide induced unconsciousness, and can be fatal at high concentrations between 500 to 1000ppm. The mucous membranes are prone to hydrogen sulfide exposure, followed by eye irritation, and have been known to cause eye disorders in Rotorua, New Zealand. Other symptoms noted by the author include: oldfactory effects where victims may experience fatigue at lower levels, headache and short-term cognitive changes, and shortness of breath. Chronic respiratory effects include respiratory disease and abnormal pulmonary function. In animal tests, hydrogen sulfide damages the cerebral cortex, cerebellum, and indications to the disruption of the brainstem and spinal cord. Guidotti also found that in humans exposure to the agent increases the risk of cardiovascular diseases and elevated risk of high blood pressure. Finally there is evidence that hydrogen sulfide at 10ppm may cause cognitive impairment. And since the smell has a very low sent threshold, the agent provokes anxiety and physiological responses even though the odor is well below the threshold for toxicity.

20. (✓) Heggie, T. W. (2009). Geotourism and volcanoes: health hazards facing tourists at volcanic and geothermal destinations. *Travel medicine and infectious disease*, *7*(5), 257-261. http://www.ncbi.nlm.nih.gov/pubmed/19747658.

Synopsis: Hydrogen sulfide is a colorless gas with a sewer or rotten egg smell that is primarily found in destinations with high geothermal activity. At low concentrations, H_2S can irritate eyes and act as a depressant. At higher concentrations, H_2S can cause upper respiratory irritation and pulmonary edema. Hydrogen sulfide is known to have resulted in tourist fatalities in various parts of Japan and the geothermal field in Rotorua, New Zealand. Exposure to 500 ppm of H_2S for 30 minutes can result in headache, dizziness, an unsteady gait, and diarrhea. It can also be followed by the development of bronchitis and bronchopneumonia. Acute exposures to >700 ppm of H_2S can result in unconsciousness within a matter of minutes and eventual death from H_2S poisoning.

21. (✓) Inserra, S. G., Phifer, B. L., Anger, W. K., Lewin, M., Hilsdon, R., & White, M. C. (2004). Neurobehavioral evaluation for a community with chronic exposure to hydrogen sulfide gas. *Environmental research*, *95*(1), 53-61. http://digitalcommons.unl.edu/publichealthresources/39.

Synopsis: "In May 2000, the Agency for Toxic Substances and Disease Registry of the US government conducted a health investigation in response to community concerns regarding ambient and indoor hydrogen sulfide (H2S), odor, and health symptoms in Dakota City, Nebraska. The objective was to determine whether adult residents in an area with repeated exposure to H2S showed poorer performance on neurobehavioral tests than unexposed residents. Study participants were required to meet age (X16 years of age) and length of residency (2 years) eligibility requirements. A battery of computer-assisted standardized neurobehavioral tests was administered in English or Spanish. A questionnaire was used to collect information about participants, demographic and health status. Three hundred forty-five people agreed to participate. After the exclusion of 10 persons, analyses were conducted on 335 participants; 171 residents in the target area and 164 residents in the comparison area. The two groups were comparable in demographic characteristics and various health conditions. Overall, neurobehavioral test results for the target and comparison groups were similar. Residence in the H2S-exposed area was associated with marginally poorer performance on a test of memory, namely, match to sample score, and a test of grip strength. However, these differences were not significant. Deficits in overall neurobehavioral performance were not associated

with exposure to H2S in this study."

22. (✓) Jordan, R.C. (2004). Summary of the toxicity assessment of hydrogen sulfide. *The secretary's science advisory board on toxic pollutants.* http://daq.state.nc.us/toxics/risk/sab/ra/H2S.pdf.

Synopsis: An evaluation of the toxicity of hydrogen sulfide was undertaken in response to a request made by North Carolina Department of Environment and Natural Resources (DENR). The Secretary's Science Advisory Board on Toxic Pollutants (SAB) compiled and examined published studies and participated in several expert presentations on the chemical and toxicological features of hydrogen sulfide and its associated chronic effects. Hydrogen sulfide can be fatal at sufficiently high exposure levels. It is can cause nerve paralysis, damage tissues along specific parts of the nose, effect metabolic enzymes levels, and on asthmatic subjects, a strong bronchoconstrictive response have occurred to controlled hydrogen sulfide exposures. Workers exposed to hydrogen sulfide experience higher rates of health related effects to hydrogen sulfide compared to non-exposed workers. SAB recommends exposure level to 0.023 ppm on humans and 0.040 ppm on asthmatics; although exposure to asthmatics should be limited to one hour while the other is based on long-term exposure (24-hour averaging).

23. (✓) Kilburn, K. H. (1999). Evaluating health effects from exposure to hydrogen sulfide: central nervous system dysfunction. *Environmental Epidemiology and Toxicology*, *1*(3-4), 207-216.

Synopsis: The study considers the effects of hydrogen sulfide on the human nervous system, pulmonary tract, heart, and other systems. Much of the associated effects are from a respiratory enzyme known as cytochrome oxide – a known poison to humans. Hydrogen sulfide can be lethal if inhaled at 70ppm for hours. Neurobehavioral impairment has been reported. In a group study, Kilburn assigned subjects to exposure levels with varying magnitude and duration of exposure. The results were 4.0 abnormalities at hydrogen sulfide levels exposure below 1ppm. Exposures in the 1 to 5ppm range resulted eight abnormalities. Levels between 20 to 40ppm resulted with 12 abnormalities. Patients exposed to levels above 40ppm had 18 abnormalities. The patterns were plausible with increased levels of hydrogen sulfide on human injury.

24. (✓) Kilburn, K. H. (2003). Effects of hydrogen sulfide on neurobehavioral function. *Southern medical journal*, *96*(7), 639-646. http://www.ncbi.nlm.nih.gov/pubmed/12940311.

Synopsis: Hydrogen sulfide exposed versus unexposed subjects were compared for physiological and psychological differences. A total of 221 patients were examined, 19 of which were exposed to hydrogen sulfide and 202 were unexposed subjects. New bystanders exposed to hydrogen sulfide did not become unconscious. However, those of whom that had been exposed had experiences at becoming unconscious (7 total). The results of the tests were such that, the group that were exposed to hydrogen sulfide performed poorly compared to the unexposed group in balancing, reaction time, color discrimination, visual performance, hearing, recognizing digital symbols, vocabulary, verbal recalling, trail making, and information exercises. Impairments associated with hydrogen sulfide were similar in the 19 workers.

25. (✓) Kilburn, K. H., Thrasher, J. D., & Gray, M. R. (2010). Low-level hydrogen sulfide and central nervous system dysfunction. *Toxicology and Industrial Health*, *26*(7), 387-405. (7): 387-405. http://tih.sagepub.com/content/26/7/387.abstract.

Synopsis: Forty-nine adults living in Lovington, Tatum, and Artesia, the source of gas/oil sector of Southeastern New Mexico were tested for neurobehavioral impairment. In the report, it was found that multiple hydrogen sulfide exposures impaired neurobehavioral functions.

26. (✓) Knight, L. D., & Presnell, S. E. (2005). Death by sewer gas: case report of a double fatality and review of the literature. *The American journal of forensic medicine and pathology*, *26*(2), 181-185. http://www.ncbi.nlm.nih.gov/pubmed/15894856.

Synopsis: The study discusses the toxic association of hydrogen sulfide and its connection to work-related fatalities. The authors report of a double fatality involving 2 workers who fell into the sewer and died from hydrogen sulfide gas. The report discusses diagnostic mechanisms, metabolism and toxicity, occurrence of incidences, and safety implications to hydrogen sulfide exposures. At concentrations of 100-150ppm, hydrogen sulfide is known to cause "keratoconjunctivitis" and respiratory irritation with lacrimation and cough. At such level, the familiar rotten egg smell is typically undetectable by sent, and may cause olfactory fatigue and/or paralyses. Depending on the level of exposure, victims may experience pulmonary edema and aspiration pneumonia. As for the two fatal victims, their cause of death was due to acute hydrogen sulfide exposure at at least 34ppm.

27. (✓) Legator, M. S., Singleton, C. R., Morris, D. L., & Philips, D. L. (2001). Health effects from chronic low-level exposure to hydrogen sulfide. *Archives of Environmental Health: An International Journal*, *56*(2), 123-131. http://www.ncbi.nlm.nih.gov/pubmed/11339675.

Synopsis: In this study, the authors compared symptoms of adverse health effects, reported by residents of two communities exposed mainly to chronic, low-levels of industrial sources of hydrogen sulfide, to health effects reported by residents in three reference communities in which there were no known industrial sources of hydrogen sulfide. The results of this study emphasize the need for further studies on the adverse health effects related to long-term, chronic exposure to hydrogen sulfide.

28. The MAK Collection for Occupational Health and Safety. Wiley On-Line 20 Library (http://onlinelibrary.wiley.com/book/10.1002/3527600418) 21

Synopsis: The MAK Collection contains nearly 3,000 publications by the Commission for the Investigation of Health 22 Hazards of Chemical Compounds in the Work Area (MAK-Commission) and provides 23 information on hazardous compounds at the workplace. Threshold values and 24 classifications for more than 1,000 substances, including H2S, are given, along with 25 toxicological evaluations and recommended monitoring methods. The MAK-Collection is 26 regularly updated with new information.

29. OSHA. (2005). Investigation of Health Effects of Hydrogen Sulfide from a Geothermal Source. *Occupational Safety and Health Administration, U.S.*

Department of Labor. www.osha.gov/.../hydrogen_sulfide_fact.pdf.

Synopsis: Occupational Safety and Health Administration describes the properties, health effect of H2S, and protection against exposure. Low concentrations irritate the eyes, nose, throat and respiratory system (e.g., burning/tearing of eyes, cough, shortness of breath). Asthmatics may experience breathing difficulties. Moderate concentrations can cause more severe eye and respiratory irritation (including coughing, difficulty breathing, accumulation of fluid in the lungs), headache, dizziness, nausea, vomiting, staggering and excitability. A level of H2S gas at or above 100 ppm is Immediately Dangerous to Life and Health.

30. (✓) Reiffenstein, R. J., Hulbert, W. C., & Roth, S. H. (1992). Toxicology of hydrogen sulfide. *Annual review of pharmacology and toxicology*, *32*(1), 109-134. http://www.annualreviews.org/doi/abs/10.1146/annurev.pa.32.040192.000545?journalCode=pharmtox.

Synopsis: Hydrogen sulfide exposures at concentrations below the current occupational limits cause physiological changes in pulmonary function, thus suggesting that asthmatics are at risk. Studies of fetal and neonatal brain tissue have shown an abnormal development, and the long-term consequences of these neuronal changes have not yet been assessed.

31. Roth, S. H., & Goodwin, V. M. (2003). *Health Effects of Hydrogen Sulphide: Knowledge Gaps*. Alberta Environment. http://www.environment.gov.ab.ca/info/posting.asp?assetid=6708&categoryid=1.

Synopsis: A few studies explored the relationship between H2S and the endocrine system, growth and reproduction, including effects on carbohydrate metabolism, smooth muscle function, and core temperature control. Since subjects were also exposed to other substances it is difficult to ascribe the effects of symptoms to H2S parse.

32. Skrtic, L. (2006). Hydrogen Sulfide, Oil and Gas, and People's Health. *Energy and resources group, University of California at Berkeley*. http://cleancounty.org/hydrogen-sulfide-oil-gas-peoples-health.

Synopsis: The study highlights the human health effects caused by hydrogen sulfide. The severity of the effects depends on the concentration of the gas and level of exposure. Its odor at concentrations as low as 0.5ppb can be detected by smell. At above 150ppb, hydrogen sulfide becomes odorless and can cause olfactory fatigue. At such level, it can also pose serious health risks and even become life-threatening.

33. Sulfur, T. R. (1997). Technical Basis for a Total Reduced Sulfur Ambient Air Quality Standard. *The Nebraska Department of Environmental Air Quality Section Implementation & Monitoring Unit.* http://www.deq.state.ne.us/Publica.nsf/c4afc76e4e077e11862568770059b73f/c9208b99934d0ce506256b6c0070cf24/$FILE/ATTAVSAQ/H2strs.PDF

Synopsis: A health risk assessment was performed to evaluate the health consequences from short-term exposure to H2S resulting from an accident or unplanned release from Puna Geothermal Venture's (PGV's) operation in Puna, Hawaii. Using worst-case analysis, the maximum levels

predicted to impact the community are less than emergency evacuation levels used by several Federal and State regulatory agencies.

34. Tatum, V. L. (1996). *Health effects of hydrogen sulfide* (No. CONF-960913). Geothermal Resources Council, Davis, CA (United States). http://helios.osti.gov/geothermal/product.biblio.jsp?&query_id=0&Page=0&osti_id=494331&PF=true.

Synopsis: "Hydrogen sulfide is a product of a number of natural processes, such as bacterial decomposition of organic matter and geothermal activity. It is a component of crude petroleum, natural gas and volcanic gases. Although high concentrations of H2S are acutely toxic, exposure to low concentrations is not generally associated with adverse health effects. Epidemiological studies overall have not demonstrated significant health effects or increased risk of cancer among workers or residents exposed to low levels of H2S and other reduced sulfur gases, and based on known mechanisms of H2S toxicity, any such effects are unlikely. However, some individuals have associated minor, subjective-type physical symptoms with exposure 10 low levels of reduced sulfur gases. The potential mechanism(s) for, or significance of, these responses are not well understood."

35. Haefner, James W. 2013. "An Explication of Two Recent Papers on the Effects of H2S". Briefing Paper for the County of Hawaii Geothermal Public Health Assessment. 11 pages. This paper is als0 listed in Annex-4 and included with all materials being made available to the County and public.

C. H2S Studies in Other Places

Costa Rica

1. Sequeira, H. G. (1999). Hydrogen sulphide dispersion model for the Miravalles Geothermal Field, Costa Rica and groundwater flow and contaminants transport models. *The United Nations University*. www.**os.is**/gogn/unu-gtp-report/UNU-GTP-1999-04.pdf.

Synopsis: The report gives results of dispersion models (Industrial Source Complex and Air Force Toxic Dispersion) of hydrogen sulfide for the Mirvalles geothermal field, followed by AQUA3D modeling to look at groundwater and contaminant transportation. The author found that the emissions from the geothermal field are below the maximum allowed limits and therefore do not represent problems for the environment or human health. Due to the complex nature of groundwater movement, the use of the AQUA3D modeling system can be an important tool to get a better understanding of the hydro-geologic processes. The study suggests long-term monitoring since the transport processes change more slowly than the flow processes. Lastly, the use of groundwater models can be used as an aid in deciding where best to monitor possible contamination.

Iceland

1. (✓) Carlsen HK, Zoëga H, Valdimarsdóttir U, Gíslason T, Hrafnkelsson B. (2012). Hydrogen sulfide and particle matter levels associated with increased dispensing of anti-hydrogen sulfide and particle matter levels associated with increased dispensing of anti-asthma drugs in Iceland's capital. *Environmental Research*. 113: 33-39. http://www.ncbi.nlm.nih.gov/pubmed/22264878.

Synopsis: The authors investigated ambient levels of hydrogen sulfide and other associated matters from geothermal plants in Iceland and the use of drugs to remedy adverse health effects. The study was conducted from March 8, 2006 to December 31, 2009 using "log-linear poison generalized additive regression models with cubic splines to estimate relative risks of individually dispensed drugs by air pollution levels". The results of the study indicate weak correlation between drugs for destructive pulmonary disease and hydrogen sulfide, and particle matter in Iceland's capital area.

California

1. Chamberlain, C. Groundwater and Volcanic Volatiles. *United States Geological Survey.* http://wwwrcamnl.wr.usgs.gov/volcwater/Isobutane.htm.

Synopsis: "The large hydrothermal system in the Long Valley caldera is thought to flow laterally southeast from an up-flow zone in the West Moat. Fumaroles form at places where permeable zones allow steam and gas from the hot fluid to reach the surface. A 40 MWe power plant has been built at one of these places, Casa Diablo. The plant pumps hot water up into a heat exchanger where isobutane is heated by the water. The isobutane vaporizes at high pressures to drive a turbine. The cooled water is then pumped back down into the ground. Occasionally, a leak develops in the heat exchanger, allowing isobutane to enter the water stream and be pumped down into the ground. Once in the aquifer, the isobutane flows with the hot water until it can boil out in a fumarolic area. It has been detected in fumaroles many km from Casa Diablo and offers proof that the underground water has been through the heat exchanger. Isobutane is a useful tracer for a number of reasons. It is inert for long periods at the temperatures and pressures of geothermal systems and is probably not appreciably adsorbed onto solid surfaces. It normally occurs naturally in only trace amounts except in areas where petroleum/natural gas occurs. It is easily detected by gas chromatography. It has a very low aqueous solubility so that it will readily separate into the vapor phase, and its presence in fumaroles will reveal the flow at depth of isobutane-tagged water. Thus it can be used in places where the liquid phase does not reach the surface. It can be used to compliment tracers that stay in the liquid phase to study boiling between injection and production wells."

New Zealand

1. (✓) Bates, M. N., Garrett, N., Crane J., & Balmes. (2013). Associations of ambient hydrogen sulfide exposure with self-reported asthma and asthma symptoms. *Environmental Research.* http://www.ncbi.nlm.nih.gov/pubmed/23453847.

Synopsis: Rotorua has the largest population exposure from geothermal emissions, in particular, high levels of hydrogen sulfide. This study investigates the associations between asthma and exposed populations. A three-year health monitoring of 1637 male and female participants from Rotorua between ages 18-65 was conducted. Exposure estimation was obtained from passive hydrogen sulfide samplers. The data collected were formatted into ArcGIS to map the concentration of hydrogen sulfide, and to see any correlation to asthmatic symptoms. The results of the study found that, overall, there was no evidence of increased asthma risk. And in some cases, asthma symptoms were reduced for those who lived or worked in higher hydrogen sulfide exposure areas.

2. (✓) Bates, M. N., Garrett, N., Graham, B., & Read, D. (1998). Cancer incidence, morbidity and geothermal air pollution in Rotorua, New Zealand. *International Journal of Epidemiology*, *27*(1), 10-14. http://www.ncbi.nlm.nih.gov/pubmed/9563687.

Synopsis: "This was an ecological study that examined cancer incidence and morbidity data for Rotorua. Cancer registry and hospital discharge (morbidity) data were obtained for the decade 1981-1990. Standardized incidence ratios (SLR) were calculated comparing Rotorua residents with those living in the rest of New Zealand. Diagnostic categories examined were based on known target organ systems of hydrogen sulphide toxicity. Of the cancer sites, there was an elevated rate for nasal cancers. However, this was based on only four cases. The SIR for cancers of the trachea, bronchus and lung in Maori women was 1.48 (95% CI : 1.03-2.06). This was not explained by higher smoking rates. In the hospital discharge data, a number of diseases showed elevated SIR, notably diseases of the nervous system and the eye. To some extent, these effects were characteristic of effects induced by hydrogen sulphide and also mercury compounds. However, there were few data with which to assess whether significant mercury exposures had occurred, and other explanations were possible. There are inadequate exposure data for Rotorua to permit conclusions on likely causal associations. However, some of the elevated disease rates were at least consistent with what one might expect to find if sufficient exposures to hydrogen sulphide and/or mercury were occurring."

3. (✓) Bates, M. N., Garrett, N., & Shoemack, P. (2002). Investigation of health effects of hydrogen sulfide from a geothermal source. *Archives of Environmental Health: An International Journal*, *57*(5), 405-411. http://www.ncbi.nlm.nih.gov/pubmed/12641180.

Synopsis: In this study, the authors classified areas within Rotorua as high-, medium, or low hydrogen sulfide exposure areas. Results showed exposure-response trends, particularly for nervous system diseases, but also for respiratory and cardiovascular diseases. The results of the study suggest that there are chronic health effects from hydrogen sulfide exposure, and that further investigation is warranted.

4. Fisher, G. W., Thornton, D., & Godfrey, J. (2007). Rotorua Airshed Modelling Investigation: Final Report. *Environment Bay of Plenty*. http://monitoring.boprc.govt.nz/Reports/Report-070900-RotoruaAirshedModellingInvestigationReport.pdf.

Synopsis: A study was conducted to assess the causes and nature of particulate matter pollution in the Rotorua region. Several methods were conducted to accomplish this including: analysis of historical air quality records, assessment of the Environment Bay of Plenty Rotorua Emissions Inventory, examining meteorological data from around the region, looking at the upper air profiles data using the Air Pollution Model, surveying the topography of the area, and using the Calmet and Calpuff models to obtain meteorological fields and to model contaminant emission over Rotorua. The results of the methods was such that high concentrations of particulate matter pollutants occur across much of Rotorua, with the main sources coming from domestic home heating emissions. The industrial emissions affect a smaller area at about 1-2 kilometers around the eastern industrial site.

5. (✓) Horwell, C. J., Patterson, J. E., Gamble, J. A., & Allen, A. G. (2005). Monitoring and mapping of hydrogen sulphide emissions across an active geothermal field:

Rotorua, New Zealand. *Journal of volcanology and geothermal research*, *139*(3), 259-269.

Synopsis: The city of Rotorua is unique in that it is located near a geothermal field, and thereby exposure from hydrogen sulfide occurs regularly to a large population of approximately 60,000 people. A network of passive data devices were developed to measure hydrogen sulfide and assess the health risks in different zones across the city. The authors show a distinct color change from white to dark brown as the concentration of hydrogen sulfide increases between 30 to 1000ppb. "The data give new insight into the subsurface routes of degassing in the Rotorua geothermal field, by showing the surface expression of the main upflow zone and the direction of the conjectured faulting below."

D. Sulfur Dioxide (SO2) Information

1. Agency for Toxic substances and Disease Registry. (1998). Public health statement: sulfur dioxide. *U.S. Department of Health and Human Services.* http://www.atsdr.cdc.gov/phs/phs.asp?id=251&tid=46.

Synopsis: According to the Agency for Toxic substances and Disease Registry, the effects of exposure to sulfur dioxide depends on the dose, the durations, how the person is exposed, personal traits and habits, and whether other chemical are present. It is a colorless gas with a distinct, strong odor. At high enough levels sulfur dioxide have been linked to cancer and birth defects. Short-term exposure to 100ppm can be life-threatening, and long-term low-level exposure of 0.4-3.0ppm impedes lung function. Asthmatics (or individuals with respiratory conditions), children, and the elderly are particularly sensitive and more vulnerable to the effects of sulfur dioxide. The Environmental Protection Agency recommends that long long-term, 1-year average concentration of sulfur dioxide should not exceed 0.03ppm; and that short-term, 24-hour average concentration should not exceed 0.14ppm more than once a year. Occupational Safety and Health Administration regulates that, in the workplace, workers should not me exposed to no more than an average of 2ppm sulfur dioxide over and 8-hour working period for 5 consecutive days in a workweek. Finally, the National Institute for Occupational Safety and Health requires that a 15-minute average exposure in air to sulfur dioxide should not be exceeded at any time during the workday at the level of 5ppm.

2. Environmental Protection Agency. (2012). Sulfur dioxide: Health. http://www.epa.gov/airquality/sulfurdioxide/health.html.

Synopsis: The Environmental Protection Agency links short short-term exposures to sulfur dioxide, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including broncho-constriction and increased asthma symptoms. Asthmatics at elevated ventilation rates are particularly vulnerable. Emissions that lead to high concentrations of sulfur dioxide generally lead to the formation of other carbon oxide. Carbon oxide, when combined with other compounds in the atmosphere, can form small particles. These particles penetrate into the lungs and can cause or worsen respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and premature death.

3. (✓) Heggie, T. W. (2009). Geotourism and volcanoes: health hazards facing tourists at volcanic and geothermal destinations. *Travel medicine and infectious disease*, *7*(5), 257-261. http://www.ncbi.nlm.nih.gov/pubmed/19747658.

Synopsis: Sulfur dioxide is irritating to the eyes, throat, and respiratory tract, and induces coughing, burning of the eyes, and difficulty breathing. While these reactions are considered relatively short-term effects, tourists with pre-existing asthmatic conditions can be sensitive to sulfur dioxide at low concentrations and suffer more severe consequences. Sulfur dioxide is known to have played a significant role in the death of several tourists at Aso, Japan, and in Hawaii Volcanoes National Park. In these situations, half of the fatalities involved asthmatic tourists. The World Health Organization (WHO) air quality guidelines have set a maximum exposure limit for sulfur dioxide at 175 ppb for 10 minutes and 44 ppb over a single day. The United States Geologic Survey (USGS) Volcanic Hazards Program notes that a concentration of 6–12 ppm of sulfur dioxide can result in the immediate irritation of the nose and throat, 20 ppm can cause immediate eye irritation, and 10,000 ppm will irritate moist skin within minutes.

4. (✓) Sheppard, D., Wong, W. S., Uehara, C. F., Nadel, J. A., & Boushey, H. A. (1980). Lower threshold and greater bronchomotor responsiveness of asthmatic subjects to sulfur dioxide. *The American review of respiratory disease*, *122*(6), 873. http://www.ncbi.nlm.nih.gov/pubmed/7458061.

Synopsis: This study determines whether subjects with mild asthma or seasonal rhinitis have greater bronchomotor responses to sulfur dioxide than normal subjects. The authors studied 7 asthmatic, 7 atopic, and 7 normal subjects ranging from ages 23 to 37. They measured the change in specific airways resistance (SRaw) provoked by 10 min of breathing 1, 3, and 5 ppm of sulfur dioxide delivered by mouthpiece on separate days at least 48hours apart. The results indicated that subjects with mild asthma develop bronchoconstriction after exposure to concentrations of sulfur dioxide well below currently accepted standards for occupational exposure, and that sulfur dioxide induced bronchoconstriction is mediated by parasympathetic pathways.

5. United States Environmental Protection Agency. (2012). Sulfur dioxide. http://www.epa.gov/airquality/sulfurdioxide/.

Synopsis: Sulfur dioxide is one of a group of highly reactive gasses known as "oxides of sulfur." The largest sources of sulfur dioxide emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). In 2010, EPA revised the primary sulfur dioxide NAAQS by establishing a new 1-hour standard at a level of 75 parts per billion (ppb).

6. United States Geological Survey. (2010). Volcanic gases and their effects. *U.S. Department of Interior*. http://volcanoes.usgs.gov/hazards/gas/index.php.

Synopsis: The United States Geological Survey identifies sulfur dioxide as a substance that affects upper respiratory tract and bronchi. The World Health Organization recommends a concentration of no greater than 0.5 ppm over 24 hours for maximum exposure. Exposure to 6-12 ppm can cause immediate irritation to the nose and throat; 20 ppm can cause eye irritation; while 1,000 ppm will irritate moist skin within minutes.

E. Carbon Dioxide

1. (✓) Badino, G. (2009). The legend of carbon dioxide heaviness. *Journal of Cave and Karst Studies*, *71*, 100-107.

Synopsis: "The false legend of carbon dioxide traps resulting from the weight of carbon dioxide gas is disproved. In spite of water-vapor lightness in comparison with air, no water-vapor trap exists on cave ceilings. In fact, underground atmospheres with specific compositions are not related to gravity, but to the absence of any air movement around the gas sources. The process of double diffusion of oxygen and carbon dioxide during organic compound decomposition in still air is shown to be significant. This phenomenon can form atmospheres that are deadly due to oxygen deficiencies and poisonous because of excess carbon dioxide. Carbon dioxide storage behaves like a liquid and can flow or can be poured, as cold air can, but these are typical transient processes with no relation to a cave's foul air formation".

F. Fluorine Information

1. Agency for Toxic Substances and Disease Registry. (2003). Environmental Baseline Study for Geothermal Development in Puna, Hawaii. *Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.* http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=211&tid=38.

Synopsis: Fluorine is a naturally-occurring, pale yellow-green gas with a sharp odor. It is very irritating to the skin, eyes, and respiratory tract. The Occupational Safety and Health Administration (OSHA) has set limits of 0.2 milligrams per cubic meter (0.2 mg/m^3) for fluorine, 2.0 mg/m^3 for hydrogen fluoride, and 2.5 mg/m^3 for fluoride in workroom air to protect workers during an 8-hour shift over a 40-hour work week.

G. Boron and Associated Gas Elements

1. (✓) Agency for Toxic Substances and Disease Registry. (2010). Toxicological profile for Boron. *Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service*. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=453&tid=80.

Synopsis: The purpose of this report is to provide the public with an overall perspective on the toxicology of boron. It contains descriptions and evaluations of the health effects of boron. Route of exposure include inhalation, oral, and dermal that can cause systemic, immunological, neurological, reproductive, developmental, genotoxic, carcinogenic, and death (although to date recording of death has occurred) depending on the level and concentration of exposure. In low levels boron causes mild irritation of nose and throat and increased nasal secretion. In significant levels, exposure can cause dryness of the mouth, nose, and throat, and dry cough, nose bleeds, and soar throat.

2. (✓) Centers for Disease Control and Prevention. (1976). Criteria for a recommended standard: occupational exposure to boron trifluoride. *The National Institute for Occupational Safety and Health and Centers for Disease Control and Prevention*. http://www.cdc.gov/niosh/docs/1970/77-122.html.

Synopsis: Specific data relating to the toxic effects of born trifluoride on humans are not available. The odor threshold of boron trifluoride has not been determined, although there are reports of rather pleasant, acidic odor was detected by personnel handling animals exposed to it at a concentration of 3.0 ppm. Others have said that boron trifluoride had a pungent, suffocating odor, but these reports do not contain data on the environmental concentrations. Cotton soded with boron trifluoride in water was placed on the skin for a day or so, which resulted in acid burn.

H. Radon

1. (✓) Barros-Dios, J. M., Ruano-Ravina, A., Pérez-Ríos, M., Castro-Bernárdez, M., Abal-Arca, J., & Tojo-Castro, M. (2012). Residential Radon Exposure, Histologic Types, and Lung Cancer Risk: A Case–Control Study in Galicia, Spain. *Cancer Epidemiology Biomarkers & Prevention*, *21*(6), 951-958. http://www.ncbi.nlm.nih.gov/pubmed/22539606.

   Synopsis: Second to smoking, radon is the largest cause of lung cancer and first to non-smokers. When exposed to concentrations higher than 50 $Bq/m^{3,}$ individuals increase their risks to lung cancer by two folds compared to those that are not. Susceptibility to tobacco smokers, are at an even higher risk of lung cancer.

2. United States Environmental Protection Agency. (2012). Appendix E: Radon. http://www.epa.gov/iaq/largebldgs/pdf_files/appene.pdf.

   Synopsis: According to the EPA, decaying radium produces radioactive gas known as Radon. Radon occurs naturally, and has been linked to lung cancer.

3. United States Environmental Protection Agency. (2012). Radon: Health Risks. http://www.epa.gov/radon/healthrisks.html#Why.

   Synopsis: It has been estimated that radon causes about 20,000 deaths each year in the U.S. It is an odorless chemical, that is also tasteless, and invisible to the naked eye. Radon is considered a carcinogen and causes lung cancer to humans.

I. Zinc

1. Center for Disease Control and Prevention. (1975). Criteria for a Recommended Standard: Occupational Exposure to Zinc Oxide. *The National Institute for Occupational Safety and Health.* http://www.cdc.gov/niosh/docs/1970/76-104.html.

   Synopsis: Zinc oxide is a white or yellowish-white, amorphous, odorless powder. Zinc oxide can be harmful when the fumes are inhaled. The fume is particularly hazardous because of its small particle size that can enter the human body, and cause damage.

2. (✓) Frederickson, C. J., Koh, J. Y., & Bush, A. I. (2005). The neurobiology of zinc in health and disease. *Nature Reviews Neuroscience*, *6*(6), 449-462. www.ncbi.nlm.nih.gov/pubmed/15891778.

Synopsis: Zinc is essential for human health, but for the environmentalists, free zinc is considered a toxic pollutant. Excess free zinc is known to be toxic to the body tissue and brain function. Fifteen-minute exposure to 300–600 μM zinc results in extensive neuronal death in cortical cell culture. These findings suggest that free zinc can cause neuronal injury.

3. (✓) Walsh, C. T., Sandstead, H. H., Prasad, A. D. S., Newberne, P. M., & Fraker, P. J. (1994). Zinc: health effects and research priorities for the 1990s. *Environmental Health Perspectives*, *102*(Suppl 2), 5.

Synopsis: The health effects of zinc are critically summarized in this report including effects on zinc deficiency and toxicology, immunological and reproductive function, and genotoxicity and carcinogenicity. The report identifies factors of risks and benefits that zinc has to human health via immune, reproductive, and neurological function, as well as the cardiovascular system. Finally, the report also looks at the biological effects of zinc at the molecular level.

J. Nickel

1. (✓) Agency for Toxic Substances & Disease Registry. (2005). Toxicological Profile for Nickel. *U.S. Department of Health and Human Services.* http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=245&tid=44.

Synopsis: This report is a compilation of toxicological information on nickel beginning with a public health statement, relevance to public health, health effects, chemical and physical information, and regulations and advisories. With regards to human health effects, the most common harmful health effect of nickel to humans is rash formation due to allergic reaction. Approximately 10-20% of the population is sensitive to nickel. Other more severe cases include chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus. Lung and nasal sinus cancers occurred in workers who were exposed to more than 10mg nickel/m^3 as nickel compounds that were hard to dissolve such as nickel subsulfide.

2. (✓) Centers for Disease Control and Prevention. (2012). Nickel. *The National Institute for Occupational Safety and Health.* http://www.cdc.gov/niosh/topics/nickel/.

Synopsis: The Occupational Safety and Health Administration (OSHA) reports of soluble nickel compounds can have adverse affects to the cardiovascular system, kidneys, and central nervous system in humans. They may also be carcinogenic to humans, while some of its compounds are linked to cause cancer to the nasal cavity and lung. According to OSHA, permissible exposure limit is 1 milligram per cubic meter (mg/m(3)) of air as an 8-hour time-weighted average (TWA) concentration. The National Institute for Occupational Safety and Health (NIOSH) recommends exposure limit of 0.015 mg/m(3) of up to 10-hours workday and 40-hours workweek. The American

Conference of Governmental Industrial Hygienists (ACGIH) recommends the limit value of 0.1 mg/m(3) as a TWA for a normal 8-hour workday and a 40-hour workweek.

3. United States Environmental Protection Agency. (1984). Health Effects Assessment for Nickel. *National Service Center for Environmental Publications.* http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000FDBJ.txt.

Synopsis: This report evaluates information on the adverse health effects associated with nickel. EPA states that regular exposure to nickel leads to the development of tumors of the nasal cavities and lungs. However, the toxicity database on nickel is limited, and therefore further studies are suggested.

K. Copper

1. (✓) Agency for Toxic Substances and Disease Registry. (2004). Toxicological profile for copper. *U.S. Department of Health and Human Services.* http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=206&tid=37.

Synopsis: Copper is both beneficial and harmful to humans. On the one hand, copper is an essential nutrient, on the other hand, it causes gastrointestinal distress including: nausea, vomiting, and/or abdominal pain in humans. Copper can also irritate the respiratory tract and has been known to cause coughing, sneezing, runny nose, pulmonary frosts, and build up of mucus. The metal has been linked to causing damage to the kidney as well as the immune system.

2. (✓) Brewer, G. J. (2010). Copper toxicity in the general population. *Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology*, *121*(4), 459. http://www.ncbi.nlm.nih.gov/pubmed/20071223.

Synopsis: The study supports the findings of copper toxicity as a causal factor of Alzheimer's disease and mild cognitive impairment. The author recommends that people should check copper levels in their drinking water and use an alternate source if it is 0.1 ppm or higher.

3. United States Environmental Protection Agency. (1984). Health effects assessment for copper. *National Service Center for Environmental Publications.* http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000FDJS.txt.

Synopsis: This report summarizes and evaluates information relevant to the health effects associated with copper. Oral ingestion can result symptoms of dizziness, headache, diarrhea, vomiting, and abdominal pain. When inhaled, copper can cause damage to lung and liver functions. Women should avoid drinking copper contaminated water as it has been reported to develop gastroenteritis.

L. Chromium

1. Centers for Disease Control and Prevention. (2011). Workplace safety and health topics: hexavalent chromium. http://www.cdc.gov/niosh/topics/hexchrom/.

Synopsis: The report indicates Hexavalent Chromium compounds to be potential occupational carcinogens. Hexavalent Chromium compounds is associated with lung, nasal, and sinus cancer. It irritates the nasal and eardrum. Dermal exposure to Hexavalent Chromium compounds can cause skin irritation, ulceration, sensitization, and allergic contact dermatitis.

2. Occupational Safety and Health Administration. (2012). Hexavalent chromium. *United States Department of Labor*. http://www.osha.gov/SLTC/hexavalentchromium/index.html.

Synopsis: Workers who are exposed to hexavalent chromium compounds in the air may develop lung cancer. The compounds irritate or damage the nose, throat, and lungs, as well as, the eyes and skin. Hexavalent chromium has been known to cause permanent eye damage and result ulcers to the mucous membranes of the nasal passages. Prolonged skin contact can result in dermatitis and skin ulcers to some workers, while other may develop an allergic reaction to chromium.

3. (✓) Wilbur, S. B., Syracuse Research Corporation, & United States. Agency for Toxic Substances and Disease Registry. (2000). *Toxicological profile for chromium*. US Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=62&tid=17.

Synopsis: The health effects of chromium depend on the typology of exposure. For instance, inhaling chromium compounds effects the respiratory system whereas gastrointestinal deficiencies are caused by oral and dermal exposures.

M. Manganese

1. Agency for Toxic Substance and Disease Registry. (2011). Manganese. http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=23.

Synopsis: Manganese is a natural substance found in rocks. Manganese is silver-colored in pure form. It can also be produced artificially to make pesticides, such as maneb or mancozeb, and used as fuel additives in gasoline. Manganese is essential for good health and can be found in several food items, including grains and cereals, and drinks such as tea.

2. (✓) Agency for Toxic Substance and Disease Registry. (2008). Toxicological profile for manganese. *United States Department of Health and Human Services.* http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=102&tid=23.

Synopsis: Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy. Existing scientific information cannot determine whether excess manganese can cause cancer, however, loss of sex drive and sperm damage has been observed in men exposed to high levels of manganese. The most common health problems to involve the nervous system include movements that become slow and clumsy.

3. Environmental Protection Agency. (2010). Ambient Concentrations of Manganese Compounds in EPA Region 5. http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewInd&lv=list.listByAlpha&r=231334&subtop=341.

Synopsis: Manganese is a naturally occurring metal. Exposure to low levels of manganese is considered to have nutritional benefits to both humans and animals. However, over-exposure is harmful and has been associated with neurological problems, such as slowed hand-eye coordination. The most recent National Air Toxics Assessment results identify manganese compounds as the largest contributor to neurological non-cancer health risk in the U.S.

N. Cadmium

1. Environmental Protection Agency. (2012). Cadmium factsheet. http://www.epa.gov/wastes/hazard/wastemin/minimize/factshts/cadmium.pdf.

Synopsis: In its purest form, cadmium is a soft silverwhite metal that naturally forms on the earth's surface. Cadmium commonly enters the body through oral ingestion and breathing. The greatest concern with cadmium is associated with long-term exposure to low dosages. Over time, cadmium can cause kidney damage. Although the damage is not life-threatening, it can lead to the formation of kidney stones and affect the skeleton. Lung damage has also been observed.

2. Occupational Safety and Health Administration. (1993). Occupational exposure to cadmium: section 5 – V. health effects. *United States Department of Labor*. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=PREAMBLES&p_id=819.

Synopsis: Cadmium is primarily linked to lung cancer and kidney damage. This is typically a result of acute exposure through the respiratory system from breathing in fumes and dust compounds. Symptoms of cadmium include fever and chest pain. In extreme cases, pulmonary edema may develop and death may occur after several days of exposure.

3. (✓) Taylor, J., DeWoskin, R., & Ennever, F. K. (1999). Toxicological profile for cadmium. *US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, GA, USA. ASIN: B002BRUYP6*. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=48&tid=15.

Synopsis: Breathing in high levels of cadmium damages the lungs and may cause death. Long-term exposure to low-levels of cadmium compounds build up in the kidney and causes damage. The U.S. Department of Health and Human Services (DHHS), The International Agency for Research on Cancer (IARC), and the U.S. Environmental Agency identifies cadmium as carcinogenic to humans.

O. Selenium

1. Occupational Safety and Health Administration. (1975). Selenium and selenium compounds. *United States Department of Labor.*

http://www.osha.gov/dts/chemicalsampling/data/CH_266500.html.

Synopsis: Selenium compounds tested in mice and rats by the oral route produced an increase in the incidence of liver tumors. The available data provide no suggestion that selenium is carcinogenic to humans, and the evidence for a negative correlation between regional cancer death rates and selenium is, thus far, not convincing.

2. (✓) Risher, J., & McDonald, A. R. (2003). Toxicological profile for selenium. *Atlanta, GA, Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services*. http://www.atsdr.cdc.gov/ToxProfiles/tp92.pdf.

Synopsis: Depending upon the level of intake, selenium can have nutritional or toxic effects. For the most part people living in the U.S. do not suffer from selenium deficiency. However, excessive intake of selenium can cause adverse health effects if doses are taken more than 5 times greater than the Recommended Dietary Allowance (RDA).

3. United States Environmental Protection Agency. (2012). Technical factsheet on selenium. http://water.epa.gov/drink/contaminants/basicinformation/historical/upload/Archived-Technical-Fact-Sheet-on-Selenium.pdf.

Synopsis: Selenium is essential for human health at low levels. However, EPA has found it to potentially cause health effects from acute exposures such as hair and fingernail changes, damage to the peripheral nervous system, and fatigue and irritability. No Health Advisories have been established for short-term exposures, although it has the potential to cause the following health effects from long-term exposures: hair and fingernail loss, damage to kidney and liver tissue, and adverse affect to the nervous and circulatory systems. Currently, there is no evidence that selenium has the potential to cause cancer from lifetime exposures in drinking water.

P. Lead

1. Agency for Toxic Substances and Disease Registry. (2007). Toxicological profile for lead. *United States Department of Health and Human Services.* CAS# 7439-92-1. http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=96&tid=22.

Synopsis: Lead is harmful to the human body, especially, the nervous system, hematological and cardiovascular systems, and the kidney. It can also increase blood pressure and cause anemia. Severe damage to the brain and kidneys can occur with high exposure to lead levels for both women and men. Pregnant women risk miscarriage when exposed to high levels of lead. In men, high levels of lead poisoning leads to organ failure and reduction in sperm count levels.

2. Occupational Safety and Health Administration. 2012. Lead. *United States Department of Labor.* http://www.osha.gov/SLTC/lead/index.html.

Synopsis: Both acute and chronic exposure to lead adversely affects the body. The level of exposure and frequency dictates the severity of medical symptoms. Acute lead exposure may cause loss of appetite, nausea, vomiting, stomach pains, constipation, insomniac, fatigue, mood fluctuations,

headache, joint or muscle aches, anemia, and reduced sex drive. Chronic exposure is linked to damage to the blood-forming, nervous, urinary, and reproductive systems.

3. United States Environmental Protection Agency. (2012). Learn about lead. http://www.epa.gov/lead/learn-about-lead.html.

Synopsis: Lead is a naturally occurring metal. It can be toxic to both humans and animals. Children are particularly vulnerable as their growing bodies absorb more lead, and their brains and nervous systems are affected greatly compared to adults. Miscarriage or premature birth can also result from exposure to lead. Adults can suffer cardiovascular functions, experience kidney failures, problems with reproduction in both women and men, and damage to the nervous system.

Q. Arsenic

1. (✓) Agency for Toxic Substances and Disease Registry. (2007). Toxicological Profile for Arsenic. *United States Department of Public Health and Human Services Atlanta, Georgia.* CAS#: 7440-38-2. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=22&tid=3.

Synopsis: This report focuses on inorganic arsenic. The toxicological profile of inorganic arsenic is poisonous to the body with oral dosage above 60,000 ppb that results in death. Ingestion of lower levels ranging between 300 to 30,000 ppb can cause abdominal pain, nausea, vomiting, and diarrhea. Other affects include fatigue, abnormal heart rhythm, and blood-vessel damage. Arsenic is also known to cause skin cancer, and when breathed-in, can cause sore throat and irritate the lungs.

2. Occupational Safety and Health Administration. Occupational safety and health guideline for arsenic. *United States Department of Labor.* http://www.osha.gov/SLTC/arsenic/.

Synopsis: This report focuses on organic arsenic. When ingested organic arsenic can burn lips, cause throat constriction, trigger abdominal pain, dysphagia, nausea, vomiting, diarrhea, convulsions, coma, and even death. Air exposure of the compound can irritate the respiratory tract, skin, and eyes. In severe cases, chronic exposure to organic arsenic can cause cancer, dermatitis, anemia, or leukocytopenia.

3. United States Environmental Protection Agency. (2005). Toxicological Review of Ingested Inorganic Arsenic. http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/arsenic/upload/2007_07_12_criteria_arsenic_sab_AsDraft_SAB.pdf.

Synopsis: Arsenic occurs organic and inorganically. This review is only of inorganic arsenic. Oral exposure to inorganic arsenic is known to cause cancer to the skin, lung, and bladder in humans. Industrial activities have increased the concentration of arsenic in the environment, often resulting in toxic concentrations of arsenic in soil, air, and water. In addition, certain geographic areas have high levels of arsenic in their underground rock formation, which can be leached and cause high arsenic concentrations in drinking water.

R. Mercury

1. (✓) Agency for Toxic Substances and Disease Registry. (1999). Toxicological Profile for Mercury. *U.S. Department of Health and Human Services.* CAS# 7439-97-6. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=115&tid=24.

   Synopsis: Humans are sensitive to the adverse affects of mercury. Mercury is associated to permanent brain damage and damage to kidneys. Breathing in mercury compounds damages the lining of the mouth and cause harm to the lungs. Inorganic mercury when ingested affects the stomach and intestines, which can cause nausea, diarrhea, or ulcers.

2. Occupational Safety and Health Administration. (2012). Occupational Safety and Health Guideline for Mercury Vapor. *U.S. Department of Labor*. http://www.osha.gov/SLTC/healthguidelines/mercuryvapor/recognition.html.

   Synopsis: Little to moderate exposure to mercury can cause fever, nausea, general malaise, tightness in the chest, chest pains, dyspnea, cough, stomatitis, gingivitis, salivation, and diarrhea. The severity increases with higher levels of mercury that include the following symptoms: weakness, fatigue, anorexia, weight loss, and disturbance of gastrointestinal function. In real severe cases, the body may tremble and spasms may occur. Changes in human behavior have been linked to mercury such as insomnia, depression, and feeling of apathy. Direct exposure can cause severe rash irritation and damage to the skin.

3. United States Environmental Protection Agency. (2012). Mercury: Health Effects. http://www.epa.gov/mercury/effects.htm.

   Synopsis: Mercury effects the neurological development. Fetus, babies, and growing children are highly sensitive to the problems associated with the chemical. Cognitive impairment, memory loss, attention, language, as well as fine motor and visual skills are vulnerable to adverse impacts from mercury.

S. Odor

1. (✓) Shusterman, D. (2001). Odor-associated health complaints: competing explanatory models. *Chemical senses*, *26*(3), 339-343.

   Synopsis: "Physical symptoms may be reported in workplace and community settings in which odorous airborne chemicals are present. Depending upon exposure concentration, duration and relative irritant and odorant potencies, a variety of pathophysiological mechanisms may be invoked in explaining odor-associated health symptoms. Some of these imputed mechanisms fall under the traditional scope of toxicology and other involve attitudinal and/or behavioral responses to odors"

2. (✓) Smeets, M. A., & Dalton, P. H. (2005). Evaluating the human response to chemicals: odor, irritation and non-sensory factors. *Environmental Toxicology and Pharmacology*, *19*(3), 581-588.

Synopsis: Smeets and Dalton examines the link between the adverse reactions of human sensory attributed to airborne chemicals and people's generated perception that stems from it. The awareness of the presence of the chemical affects people's perceptions and interpretations of their chemical environment. In particular, unpleasant chemical odor can cause anxiety and stress that lead to adverse health effects.

T. Vibration

1. Laurie, Sarah. 2003. Summary of Recent Observations of Adverse Health Effects from Wind Developments. *National Wind Watch*. http://www.wind-watch.org/documents/summary-of-recent-field-observations-of-adverse-health-effects-from-wind-developments-in-australia/.

Synopsis "Just as there is an acute form of vibration injury form turbines called Wind Turbine Syndrome, there is an acute form of injury from geothermal energy production, which might be called Geothermal Plant Syndrome. The result of chronic exposure in each case would be Vibro-Acoustic Disease (VAD). It is also clear from this report (and others) that people who have already suffered from chronic exposure to Infrasound and Low Frequency Noise (ILFN) are more sensitive to noise pollution. This is an important factor in understanding how different people respond to geothermal noise. This article makes a very important addition to understanding the health impacts of geothermal despite its focus on win turbines."

U. Noise

1. Colby, W. D., Dobie, R., Leventhall, G., Lipscomb, D. M., McCunney, R. J., Seilo, M. T., & Søndergaard, B. (2009). Wind Turbine Sound and Health Effects. *An Expert Panel Review*.

Synopsis: In response to some concerns that sounds emitted by wind turbines cause adverse health effects, a multidisciplinary expert panel was gathered to review, analyze, and discuss the merits of the claims against an extensive literature review and review of potential environmental exposures. The expert panel found no evidence of physiological effects from sounds from wind turbines, nor do vibrations from turbines generate enough frequency to affect human health.

2. European Environment Agency. (2010). Good practice guide on noise exposure and potential health effects. http://www.eea.europa.eu/publications/good-practice-guide-on-noise.

Synopsis: This paper presents the current knowledge about the health effects of noise. The effects of noise can range from annoyance to cognitive impairment. At an emotional level, it can cause feelings of discomfort, anger, depression, and helplessness. When sleep deprivation occurs due to noise disturbances, it can lead to physical ills such as heart disease, high blood pressure, and hypertension. Noise can also cause dramatic loss to cognitive and emotional function, and may influence learning and performance. A risk assessment is provided in the document, along with some cost-benefit analysis, and some implications for people's quality of life.

3. Goelzer, B., Hansen, C., & Sehrndt, G. (2001). Occupational exposure to noise: evaluation, prevention and control. Dortmund, Germany: *World Health Organization*. http://www.osha.gov/SLTC/noisehearingconservation/healtheffects.html

Synopsis: According to the authors, high noise levels present a number of adverse human health effects including increase in blood pressure, sleep deficiency, and permanent hearing impairment. The only viable solution to noise impact is prevention. The literature starts with the fundamental of acoustics, the occupational causes to hearing loss, and implications for noise reduction strategies. It is followed by evaluation of exposure to noise and legal provisions that are required in order to minimize impact. In conclusion, the authors stress the importance of standardizing noise control, which begins at the designing stage of the given project or industry.

4. (✓)Passchier-Vermeer, W., & Passchier, W. F. (2000). Noise exposure and public health. *Environmental health perspectives*, *108*(Suppl 1), 123. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1637786/.

Synopsis: "There is sufficient scientific evidence that noise exposure can induce hearing impairment, hypertension and ischemic heart disease, annoyance, sleep disturbance, and decreased school performance. For other effects such as changes in the immune system and birth defects, the evidence is limited. Most public health impacts of noise were already identified in the 1960s and noise abatement is less of a scientific but primarily a policy problem. A subject for further research is the elucidation of the mechanisms underlying noise-induced cardiovascular disorders and the relationship of noise with annoyance and nonacoustical factors modifying health outcomes. A high priority study subject is the effects of noise on children, including cognitive effects and their reversibility."

4 Other Resource Materials

(Note: This is a list of miscellaneous materials that were collected during the course of the Study Group's deliberations and are provided to the County in full for the County's and public's use.)

I. Act 97
- a. SB3003 HD2 Act 97

II. PGV Incident Responses
- a. Historical Incident Responses, 13 April

III. Annual Pentane Reports
- a. January 1, 2008 to December 2012

IV. Arsenic
- a. Arsenic in Groundwater
- b. Occupational Safety and Health Guideline for Arsenic - Source available exclusively online at http://www.osha.gov/SLTC/arsenic/
- c. Toxicological Profile for Arsenic
- d. Toxicological Review of Ingested Inorganic Arsenic

V. Boron
- a. Criteria for a Recommended Standard Occupational Exposure to Born Trifluoride
- b. Toxicological Profile for Boron

VI. Briefing Papers
- a. Briefing Paper 1: General Roadmap for the Process
- b. Briefing Paper 2: Gauging Scientific and Technical "Robustness"
- c. Briefing Paper 3: A Brief Profile of Puna's Demographies, Health Conditions, and Geothermal Complaints

VII. Cadmium
- a. Cadmium Factsheet
- b. Occupational Exposure to Cadmium: Section 5 – V. Health Effects – Source available exclusively online at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=PREAMBLES&p_id=819
- c. Trends Analysis for Specific Priority Chemicals (2005 – 2007): Cadmium and Cadmium Compounds (Cadmium)
- d. Toxicological Profile for Cadmium

VIII. Chromium

a. Hexavalent Chromium - Source available exclusively online at http://www.osha.gov/SLTC/hexavalentchromium/index.html
b. Public Health Statement: Chromium
c. Toxicological Profile for Chromium
Workplace Safety and Health Topics: Hexavalent Chromium - Source available exclusively online at http://www.cdc.gov/niosh/topics/hexchrom/

IX. Copper

a. Copper toxicity in the General Population
b. Health Effects Assessment for Copper
c. Toxicological Profile for Copper

X. Fluorine

a. A Geochemical Trophic Cascade in Yellowstone's Geothermal Environments
b. Atmospheric Dispersion, Environmental Effects and Potential Health Hazard Associated with the Low-Altitude gas plume of Masaya Volcano, Nicaragua
c. Fluorite Solubility Equilibria in Selected Geothermal water
d. Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine

XI. Friends of Puna Geothermal Venture

a. Geothermal Energy and Hydrogen Sulfide_1
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k. Hydrogen Sulfide Dispersion Consequences Analysis in Different Wind Speeds: A CFD Based Approach
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m. Investigation of Health Effects of Hydrogen Sulfide from a Geothermal Source (Rotorua)
n. Low-level Hydrogen Sulfide and Central Nervous System Dysfunction
o. Neurobehavioral Evaluation for a Community with Chronic Exposure to Hydrogen Sulfide Gas
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5 Project Description

September 27, 2012
Peter S. Adler, PhD
Tel: 808-888-0215
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Project Web Site: http://www.accord3.com/pg68.cfm

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1 Why this project?

Public officials, regulators, and residents must consider the potential health risks that may be associated with geothermal energy production. Historically, health complaints -- respiratory problems, sleep disturbances, nausea, dizziness, and others -- have been attributed to emissions from the plant. Sorting out the facts is challenging.

Science coming from one or two data sets is rarely definitive. More often, answers emerge from a fabric of studies. In the case of geothermal health impacts, research-based and clinical information is scattered across different geothermal energy producing areas like California, Philippines, Indonesia, Mexico, New Zealand, and Iceland. Getting clarity and insight for Hawai‘i is an important work in progress.

This project, initiated by the County, will bring together an independent Study Group with diverse expertise: associated scientific disciplines, medical experts, and knowledgeable community representatives.

2 What will it do and what will get produced?

First, it will bring together a reasoned, sustained, and science-focused deliberation to capture in one document a listing of the public health questions pertinent to the production of geothermal energy in the Puna region.

Second, it will create a reliable inventory of existing studies that address the public health concerns surrounding geothermal plants and other H2S emitting facilities around the world to serve as a baseline for the current state of knowledge on the topic.

Third, it will develop a set of recommendations about the priorities and preferred methodologies for future scientific and monitoring studies that may be required or

that can best assist the County and the Windward Planning Commission to make informed decisions that protect the long term health of the neighboring communities that surround geothermal energy development on Hawai‘i Island.

3 What questions will the group will take up?

Once assembled, the Study Group will formulate its own key questions and seek to gather together the best available information. These could include, among others:

- What is in the geothermal steam coming through the PGV facility, how is it similar or different from other production facilities, how safe or dangerous is it, and at what exposure levels?
- What specific health complaints have been attributed to geothermal energy production, by whom, and when?
- What is known about the toxicity, exposure levels, and health impacts of chemicals other than H2S?
- What kinds of long-term records of steam and fluid releases are in place, who has them, and what do they tell us?
- What are the background ambient conditions and how distinguishable are those from somewhat higher, intermittent impacts?
- What do we know about quality of air and its monitoring in and around PGV and in other nearby areas of Puna?
- How can health problems that might be attributable to geothermal production be distinguished from those that may be attributable to ambient air and ground conditions?
- What studies have been done that establish actual or potential correlations between spikes in emissions and spikes in health complaints?
- Do wind and other climate conditions affect health complaints?
- What is the current state of knowledge about the short or long-term health issues that may be associated with reinjection from the geothermal energy plant?
- What are the best methodological approaches to study the issues in a way that produces high quality information for decision-making?
- What constitutes a defensible health assessment study?
- What is the recommended priority of studies that need to be undertaken?

4 Will the project produce original research?

No. The project will be as summative as possible of current research-based knowledge.

5 Why do it then?

The County needs a robust roundup of what we know, don't know, and still need to know about health impacts that may be associated with geothermal energy production. Joint Fact-Finding brings experts and knowledgeable stakeholders together to focus on factual questions. JFF procedures are flexible but usually have six characteristics. They are:

(1) Composed of people who have different kinds of expertise and different views;
(2) Collaborative and require people to work together to improve on existing knowledge;
(3) Structured, meaning that meetings are well designed and highly focused;
(4) Inquiry based and require a robust exploration to understand perceived problems from all angles;
(5) "Study" processes and not forums for arguing political positions; and
(6) Integrative and multidisciplinary.

6 Who will be responsible for independently convening, facilitating, and reporting on the results of the Study Group?

Peter S. Adler, PhD will serve as Project Director (bio attached below). He and his team will operate at arm's length from elected officials and pro- or anti-geothermal energy advocates.

7 How will the project work?

The Project Director and his team will bring together an initial inventory of existing studies and other baseline information. Simultaneously, interviews with 15-25 people will be conducted to identify (a) potential health related issues to be flagged for study; and (b) the potential expertise needed to populate an effective Study Group. Using graduate student researchers and an assistant, a more expansive set of reference documents will be annotated and made available to Study Group members both electronically and in a binder. This will ultimately be made available to the public on the County's website.

The Study Group itself will convene for an anticipated set of 5 meetings over a 3-5 month period with information gathering taking place between meetings. The first meeting will establish full understandings on scope of the project and rules of the road, engage preliminary thinking on geothermal health issues, and take a first pass at identifying, characterizing and categorizing actual or potential health questions to be studied.

While the process will remain flexible, the Study Group's anticipated second meeting will review information gathered and undertake a first pass at evaluating the strength and relevance of various issues. The third meeting will undertake a rough ranking of issues in terms of their scientific and technical levels of hazard and exposure, prepare a possible sequence for future study and monitoring, identify preferred methodologies and develop a list of the types of expertise needed to conduct future studies and monitoring.

The fourth meeting will be a public presentation of the Study Group's preliminary findings in power point form with an open invitation to provide substantive comments and ideas. Following this meeting, the group will consider the comments, additions and ideas that have been received, prepare a first draft, and submit it to three independent reviewers. A fifth and final meeting of the Study Group will be held to conclude a final report will be submitted to the Administration, the County Council, and The Windward Planning Commission and the report posted on the County's website.

8 How can persons submit information on relevant studies or other data that the Study Group should consider?

As the project proceeds, materials will be posted at http://www.accord3.com/pg68.cfm. Three sub-folders have been established. "Background" contains Adler's resume, a Statement of Independence, and several science-articles. "Bibliography" will be the location where studies and research materials are posted. This section will be updated periodically. "Meeting Announcements" will carry announcements of Study Group meetings and other materials pertinent to those meetings.

The Study Group will also welcome comments at geothermalhealth@gmail.com.

Peter S. Adler, PhD is a principal in ***ACCORD3.0*** which specializes in foresight, strategy, joint fact-finding and non-routine problem-solving. Adler has worked in the government, business and NGO sectors. He teaches advanced problem-solving courses in the Department of Urban and Regional Planning at the University of Hawaii, and represents the USDA's Agricultural Mediation Program in Hawaii. Prior organizational experience includes nine years as President and CEO of The Keystone Center (www.keystone.org), Executive Director of the Hawaii Justice Foundation, and founding Director of the Hawaii Supreme Court's Center for Alternative Dispute Resolution. He is the author of three books and numerous chapters and articles.

6 Study Group Charter

I Purpose

This document describes the purposes and procedures of the Geothermal Public Health Assessment Group ("Study Group") and is intended to help us meet our aspirations and schedules and engage in disciplined and productive discussions.

II Mission

The project, initiated by the County but conducted independently and at arms-length from political or advocacy agendas, brings together knowledgeable scientific, medical and community voices to try to accomplish three purposes:

First, we will undertake a sustained and science-centered deliberation to capture in one document a listing of the highest priority public health questions pertinent to the production of geothermal energy in the Puna region.

Second, we will create and evaluate the most reliable inventory of existing studies available to address public health concerns.

Third, we will develop recommendations as to the priorities and preferred methodologies for future scientific and monitoring studies. These may be required to assist the County and the Windward Planning Commission to make informed decisions as they relate to expenditures of the Geothermal Asset Fund and its use to help finance appropriate health studies related to the geothermal energy development in the Puna region.

III Membership

The members of the Study Group are:

- Jay Bondesen
- Alfred Dettweiler
- Dan DiDomizio, M.P.H., P.A.
- Edward Fisher, Ph.D., R.Ph.
- James Haefner, Ph.D.
- LaRee Ann Hiltner, M.S.
- Robert Petricci
- René Siracusa, M.A.
- A. Jeff Sutton, M.S.
- Laura Travis, R.N.
- Thomas Travis, Captain - USN (Ret)
- Maile Tualiʻi, Ph.D.

IV Leadership, Organization, and Coordination

The project is organized and facilitated by Peter S. Adler, PhD of *ACCORD3.0*, assisted by Ms. Keala Carter and Mr. Xavier Matsutaro. Adler's "Statement of Independence" is posted at the project website at www.accord3.com/pg68.cfm.

Adler, Carter, and Matsutaro will be responsible for coordination, facilitation, logistics, and communication.

For members of the Study Group, this will be a cooperative and non-adversarial process. The job of the organizers is to help the Study Group to be tough on the issues and collegial with each other. Adler and his team will help the Study Group prepare for and manage meetings, help identify and prioritize critical issues, organize study materials, and chair the deliberations so that purposes are accomplished. More specifically, they can be expected to:

- Ensure that a reasonable and diverse range of perspectives are brought to bear on all discussions.
- Ensure that no one group or person is allowed to dominate discussions or disadvantage the expression of other perspectives.
- Remain impartial on the substance of the issues being discussed while proactively ensuring that all Study Group members collectively prioritize which issues are most important to study and discuss.
- Consider the collective Study Group as their "client"
- Ensure that members of the Study Group understand that they cannot use Adler and his team to advance any pro- or con- advocacy agendas.
- Encourage members of the Study Group to work together, build and maintain cohesion, and work towards the highest levels of congruent, fact-informed conclusions that can be achieved.
- Encourage the fullest disclosure and exchange of information vital to accomplishing the Study Group's three goals.

V Schedule

With flexibility, and subject to revisions, the Study Group will meet for at least five anticipated meetings at dates and times to be established and seek to complete our work by March 31, 2013.

VI Rules of the Road

1. Study Group members serve as volunteers and participate because they have mutual interests in sorting out the best scientific conclusions that can be distilled from different data sets and research findings.
2. Study Group members bring different types of knowledge, experience, and expertise to the table and are highly valued for that.
3. Members are participating individually and represent their own views only, not those of the organizations or agencies that they may be affiliated with.
4. While every effort will be made to schedule briefings and meetings at a time convenient to the most members, to ensure continuity, Study Group members may not send alternates. If a meeting must be missed, they are free to send observers to supplement the meeting notes that will be made by Adler and his team.

5. The Study Group may hold teleconferences, webinars, or briefings with other experts between meetings.
6. Barring logistical barriers or the inability to conduct civil deliberations, a majority of meetings will be held in or close to the Puna area and will be open for others to observe. Whenever possible, time will be provided at the end of meetings for observers to (a) ask questions for information or clarification and (b) offer comments that are relevant to the scientific matters being examined. Questions and comments must pertain to the science of geothermal health.
7. Sessions may be video or audio recorded and posted to websites provided they are recorded in their entirety and not edited so as to take portions out of context.
8. Media are welcome but will be treated as observers. Their questions will be accepted at the end of the meetings with others.
9. No individual member of the Study Group will speak for the Study Group. Nor will Adler characterize the substance of the deliberations other than to describe the process.
10. As a matter of good faith and to avoid distraction, Study Group members will withhold public comments and personal evaluations of the content and process of the Study Group until the process is completed.
11. Documents, research materials, notes from meetings and other materials will be uploaded to http://www.accord3.com/pg68.cfm.
12. Candor is prized but the courtesies and etiquettes conducive to high quality deliberation are expected, i.e. sharing airtime; listening to others; focusing on factual information; not monopolizing discussions; staying on topic.

VII Decision Making

There will be numerous smaller and larger decisions to be made. Procedural decisions may range from the locations, dates and times of meetings to matters of bibliographic research. Substantive decisions will range from the priority of issues to be studied, the specific studies to be discussed, and recommendations as to future studies and methodologies that should be provided to the County.

Wherever possible, the Study Group will operate by the highest consensus possible. Consensus decisions are those everyone in the Study Group can support, or at a minimum, for which there is "no objection." When, after discussion, consensus proves impossible, the Study Group will take votes of those present which will be recorded. Major concluding decisions will be deferred until all members of the Study Group are present, or done by telecom, or by e-mail.

VIII Inquiries

Inquiries about the project and the process may be directed to: Peter S. Adler, PhD at geothermalhealth@gmail.com. Adler can also be reached at 808-888-0215. The project website is also openly accessible at http://www.accord3.com/pg68.cf